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1. City of Panama, the Pacific End of the Canal (the cross shows the mouth of the canal). 2. Last Glimpse of Panama. 3. Canal Works, Panama Railway, and Chagres River at Culebra. 4. Valley of Buenavista and Canal Works. 5. Cutting at Gatoon and Chagres River. 6. Steam Navvy at Work. 7. Dredge Working at the Mouth of the Canal, Colon. 8. The Effect of Malaria. 9. Canal Works and Steam Dredger, Chagres River. 10. Colon, the Atlantic Mouth of the Canal (the cross shows the mouth of the canal).

FROM THE PACIFIC TO THE ATLANTIC ALONG THE ROUTE OF THE PANAMA CANAL. (See next page.)

THE PANAMA CANAL.

CONSIDERING the magnitude of the undertaking, and the great boon which will be conferred on navigation by its construction, the works of the Panama Canal, which are now being so vigorously carried on, are attracting singularly little attention. The majority of people have a very vague notion of the progress of the rival waterway in the Western Hemisphere, which its promoter assures us will join two oceans in a couple of years' time. Our illustrations are from *The London Graphic*, and drawn by Dr. E. J. Mulligan, of the Royal West India Mail Service, who also gives the following particulars:

The distance from ocean to ocean is about fifty miles, and with the prospect of passing swamps, through valleys, and rocky defiles, and over mountains, the farewell sight of Panama and the Pacific, seen through the transparency of the bluish mist, reflecting the golden rays and rosy tints of a tropical sun, is a most imposing spectacle. Panama is in every respect a superior place to the Atlantic terminus, Colon. The ruins of the old Spanish city, which dates from 1593, may be seen outside the present town in the form of marble fragments, moss clad columns, and huge pieces of masonry—reminding one of the buccaneer exploits of Drake, Morgan, and L'Olonois, who so frequently attacked the city and carried off the merchants' gold and treasure. The present town contains a quaint old cathedral, and the inhabitants are of a higher type than the colonies, there being several literary and scientific societies. The bay, with its fairy-looking islets, is not unworthy of comparison with the Bay of Naples. The Pacific mouth of the canal will open to the northward of the city. On the Atlantic side the canal will open about a mile northward of Colon.

The scenery of the Isthmus throughout the route of the railway and the Canal works is generally picturesque. One attractive characteristic is the richness and beauty of the glades and vistas of luxurious tropical vegetation; an additional feature of loveliness is seen in the variety and richness of the flowers which grow on all sides, as clusters of crimson, white, and blue blossoms crown the trailing plants, and orchids, parasites, marsh lilies, ferns, and purple-topped osiers grow together, forming a kind of floral paradise. Although such a happy looking land, the Isthmus is really a "Valley of the Shadow of Death," owing to the terribly fatal effects of the malaria among the laborers. As shown in one of the sketches, the dead body of a negro may occasionally be found, who has succumbed to fatigue, hunger, and fever. As if by instinct, flocks of somber-looking turkey-buzzards appear on the scene—Nature's scavengers. The Chagres River, the railway, and the Canal meet at various points of the Isthmus, occasionally run alongside of each other, diverge, and come together again, as at Culebra—a station eight miles from Panama, and thirty-seven from Colon, and where the scenery is exceedingly picturesque, but the climate malarious and depressing.

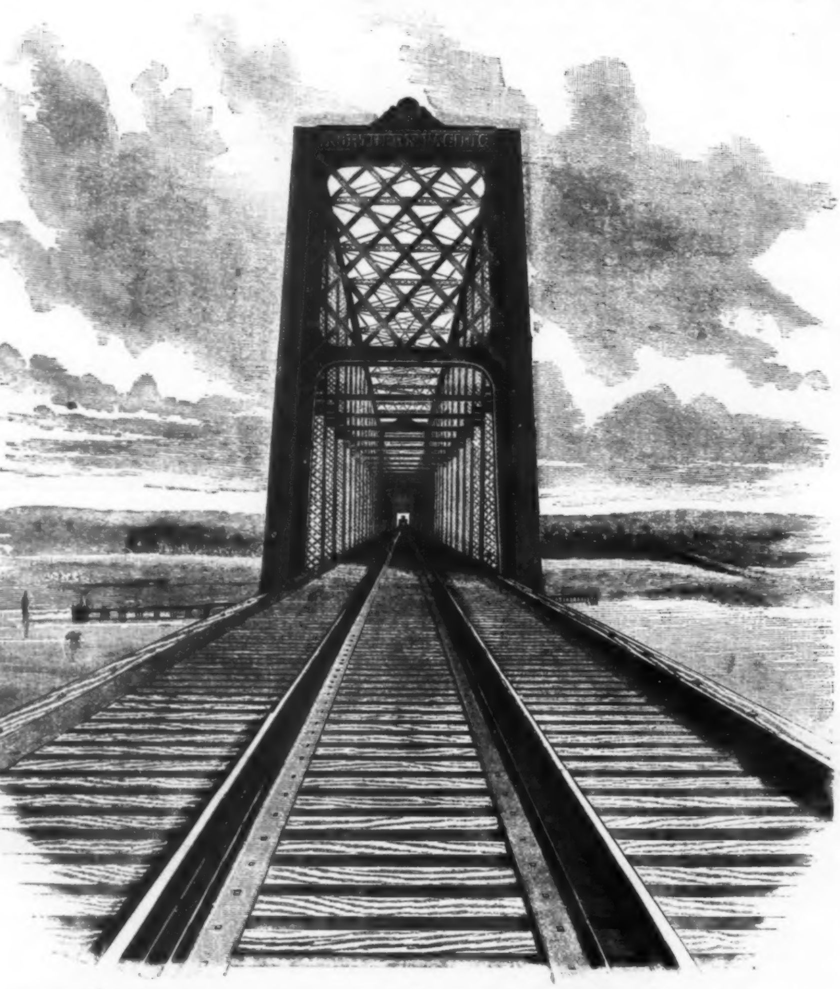
Another sketch represents the valley of Buenavista, where great advance has been made in cutting and clearing wood, blasting rocks, and laying down a line of rails. It was there last June that a gang of the negro laborers came into collision with some new comers, a desperate encounter was the result, and fifty persons were killed. Gatoon, like the last-named place, promises to become a special station. It is about ten miles from Colon, and close to the Chagres River, and is the principal depot of all the mechanical appliances. At this place there is one of the great steam-excavators at work.

M. De Lesseps' energetic staff of engineers are at present busily engaged in excavating, boring, and mining operations, with vast machines of the most intricate description working at different points on the slopes and elevated positions. Gangs of laborers also, numbering from fifty to three hundred, can be seen slicing the hill sides into miniature precipices, forming terraces and roads, laying down sleepers, and cutting passes through dense forests. Workshops are erected at Colon, where the massive segments of machinery which are continually landed from Belgium are placed together. There the incessant ring of hammers is heard day and night, furnaces are glowing, and riveters are welding huge plates together. Colon is the Atlantic outlet of the Canal; but it is not an attractive resting-place for travelers, being an unimposing, unhealthy, dirty locality; but it is interesting because it is the spot where Columbus is supposed to have landed. From the sea it presents the appearance of a range of straggling, irregular buildings on a low sandy beach, with landing-stages jutting out into the water. The houses are of wood, and gaudily painted; and provided, in the Spanish style, with verandas and balconies. The streets are filthy, and are chiefly remarkable for the tobacco and grog shops, American drinking saloons, and low gambling-houses. The great body of inhabitants are mere desperadoes, the dregs of the Colombian States, who perpetrate crime without fear of punishment. However, the natives met with in crossing the Isthmus are happily of a different class, and may be seen selling provisions and refreshments to the laborers of the Canal, such as grapes, bananas, eggs, cocoa-nuts, melons, etc. They are of a mixed Indian and Spanish type, with austere expression, long, thin features, keen eyes. The women are simply attired, and generally display a profusion of black, glistening hair falling over the shoulders in two large braided plaits reaching down to the hips. The natives are inoffensive and affable if unmolested, but savage and revengeful if injured.

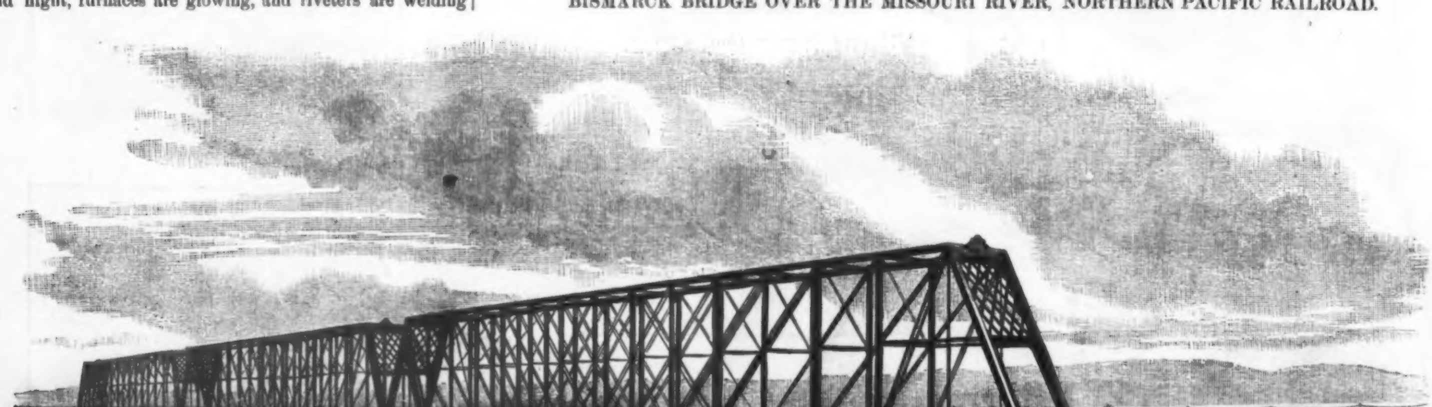
For profile of the Canal and the whole history of the Canal enterprise, with many illustrations, see back numbers of the SCIENTIFIC AMERICAN SUPPLEMENT.

BISMARCK BRIDGE OVER THE MISSOURI RIVER AND NORTHERN PACIFIC RAILWAY.

ON January 28, 1881, a contract was let to the well known firm of Saulspaugh & Co., of Rock Island, Ill., for the construction of the substructure of the bridge, this including the foundation and masonry of the four piers. In April the quarrying of stone was begun near Watab station, in



BISMARCK BRIDGE OVER THE MISSOURI RIVER, NORTHERN PACIFIC RAILROAD.



BISMARCK BRIDGE OVER THE MISSOURI RIVER, NORTHERN PACIFIC RAILROAD.

Minnesota, but the quarry not proving a good one another was subsequently opened near East St. Cloud. This last quarry, now known as the Rock Island quarry, furnished four-fifths of the stone used in the Bismarck Bridge. A sub-contract for the pneumatic work of the two channel piers was made by Messrs. Sauispaugh & Co. with Messrs. Rust & Coolidge of Chicago.

On February 2, 1881, a contract was awarded to the Detroit Bridge and Iron Works, of Detroit, Michigan, for the manufacture and erection of the superstructure, consisting of three through spans of 400 feet each and two deck spans of 113 feet each, the work to be built in all respects according to the detailed plans and specifications prepared by the engineer of the bridge.

strong, but when exposed to the dry air the clay slakes rapidly and crumbles to pieces.

The east end of the east approach span is supported by a small abutment of granite masonry founded on the natural ground of the bluff. The west end of the west approach span is supported by an iron bent resting on two Cushing cylinders which are supported by piles driven into the sand bar.

The three long spans are supported on four granite piers.

Pier I., the easterly pier, rests on a concrete foundation, the base of which is 20 ft. below ordinary low water and 16 ft. below the estimated extreme low water due to ice gorges.

Piers II. and III., which are in the channel of the river, are founded on pneumatic caissons sunk into the underlying clay to a depth of about 50 ft. below ordinary low water, and 10 ft. below the surface of the clay.

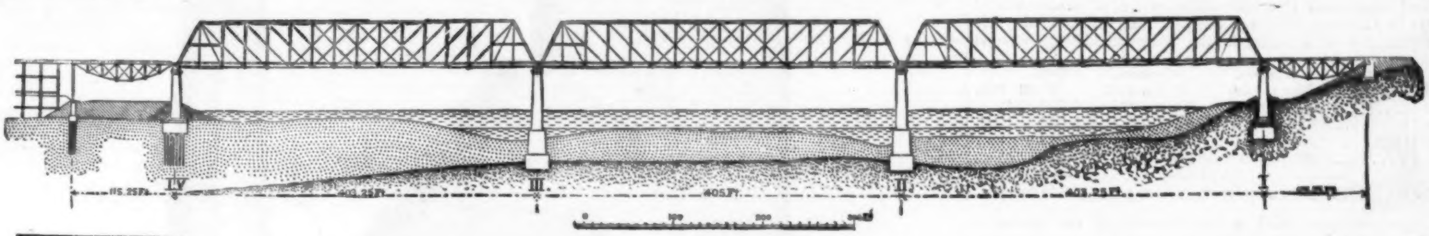


Fig. 5.

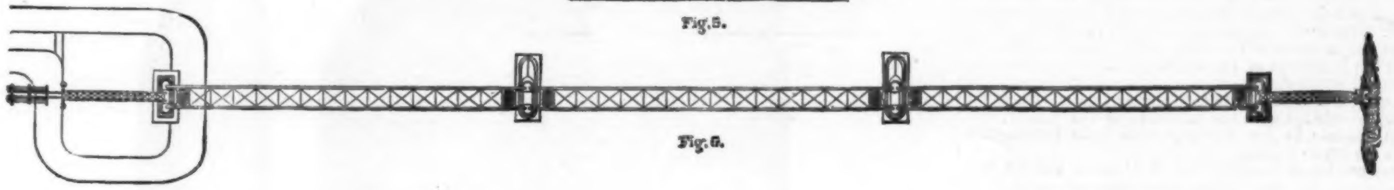
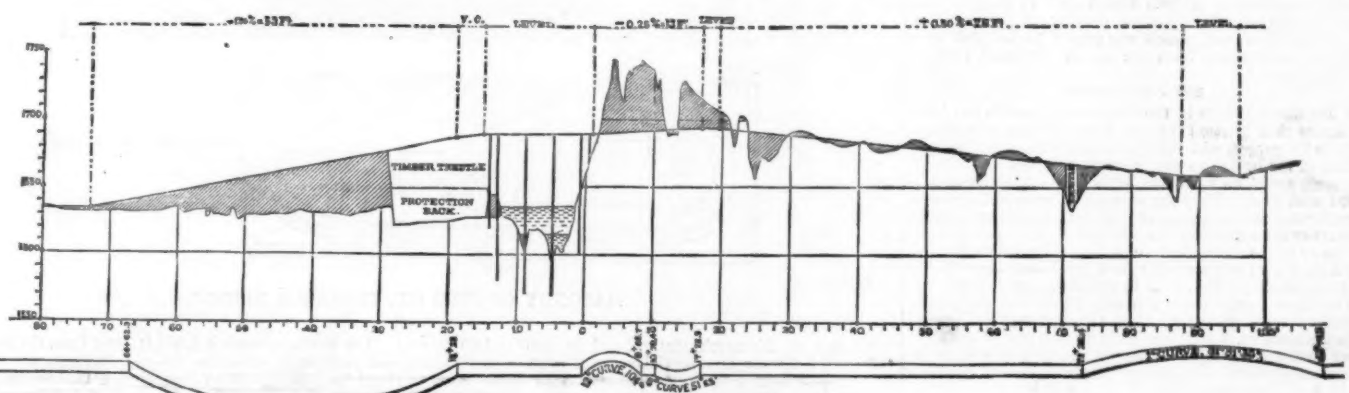


Fig. 6.



ALIGNMENT

Fig. 7.

THE BISMARCK BRIDGE OVER THE MISSOURI RIVER NORTHERN PACIFIC RAILROAD.

In April the construction was fairly begun, though ground was not actually broken until May.

The construction of the Bismarck Bridge involved three different pieces of work:

First, the control and rectification of the river.

Second, the bridge proper.

Third, the approaches.

The control and rectification of the river consisted in confining it to the 1,000 foot limit between the east shore and the end of the dike, and the protection of the east shore with riprap so as to render it doubly secure from the eroding action of the water.

There have been used in the construction of the dike 30,000 tons of granite bowlders for riprap, besides a large quantity of brush and crib logs, and upward of 28,000 cubic yards of clay.

The action of the dike has been such as to satisfy the engineers of the correctness of their plans. The river has been permanently confined to a width of 1,000 feet adjoining the east shore. A thick growth of willows has started spontaneously on the deposit formed by the river in what was the main navigable channel adjoining the west shore. The course of the channel is gradually improving.

The elevation of the top of the dike was purposely fixed at about the level of ordinary summer floods, this height being thought likely to secure a larger deposit both above and below the dike than if finished at a higher level. When the ice goes out, about the first of April, the water usually rises some feet above the top of this dike, and a secondary embankment, intended only to resist the action of ice, has been built immediately alongside of the trestle approach, this embankment finishing nearly 20 feet higher than the top of the dike.

Our engravings are from the *Railroad Gazette*.

The bridge proper consists of three through spans, each measuring 400 ft. between centers of end pins, and two approach spans each 113 ft. It is a high bridge, the bottom chord of the three main spans being placed 50 ft. above the level of the highest summer flood, thus giving head room to pass steamboats at all navigable stages of the river. The head room above the extreme high water of 1881 is 42 ft., but this water was an exceptional result of an ice gorge which necessarily put a stop to all navigation. Practically, the bridge gives 4 ft. more head room than many of the bridges on the lower river.

With the exception of some thin strata of soft sandstone of irregular thickness and extent, no rock is found in position in this part of Dakota. The entire country is underlaid with a very hard stratified clay, the depth of which has not been ascertained. Borings proved this clay to be at least 100 ft. thick on the line of the bridge, and a hole intended for an artesian well has since been sunk within the Bismarck city limits to a depth of over 1,300 ft. in the clay. This clay, however, is in many respects more like a rock than a clay; small specimens tested for compression have sustained a weight of over 300 pounds per square inch without crushing, and when they gave way yielded like rock, and showed no tendency to bulge out at the sides. Water has little or no effect upon this clay, even where the current is extremely

Pier IV. is situated on the sand bar on the west side of the river, below the protection of the dike, and rests on a foundation of 160 piles, which were driven with a Nasmyth steam hammer.

THE CAISSONS

on which piers II. and III. are founded are built of pine timber, and are shown by Figs. 8, 9, 10, and 11, sheathed with two thicknesses of 3-in. oak plate. They measure 74 ft. long by 26 ft. wide, by 17 ft. high on the outside. The lower portion of the caisson forms a working chamber 7 ft. high, with flat roof and inclined sides. The upper portion of the caisson is a crib-work of timber filled throughout with Portland cement concrete. Each caisson contained 133,000 ft., board measure, of timber, and 82,000 pounds of iron, besides nearly 500 cubic yards of concrete.

The caissons were built on shore, launched, and towed into position. After the caisson had been placed, the concrete above the working chamber was put in, the air locks put in position, and air pumped into the working chamber, which was thus converted into a great diving-bell, until the water was expelled. A force of men was then put to work in the working chamber, who excavated the sand, which was carried off in columns of water, and the caisson was forced down gradually by its own weight as the excavation proceeded. The masonry was laid on the roof of the caisson and continued as the sinking progressed, the top of the masonry being always kept above water. This laying of masonry on a sinking foundation was a source of serious perplexity to the masons, who were greatly troubled when they found they could no longer make use of a level to set their stone, one man making the brilliant discovery that the level must not be used, but that everything must be set with the plumb.

The air lock used, Figs. 12, 13, and 14, was of peculiar construction, designed especially for this work. It consisted of two semicircular chambers, each having a diameter of 6 ft., separated by two spaces each 3 ft. square; one of these intermediate spaces connected with the shaft descending into the caisson, and the other with the shaft which led up through the masonry to the air above; each of the semi-

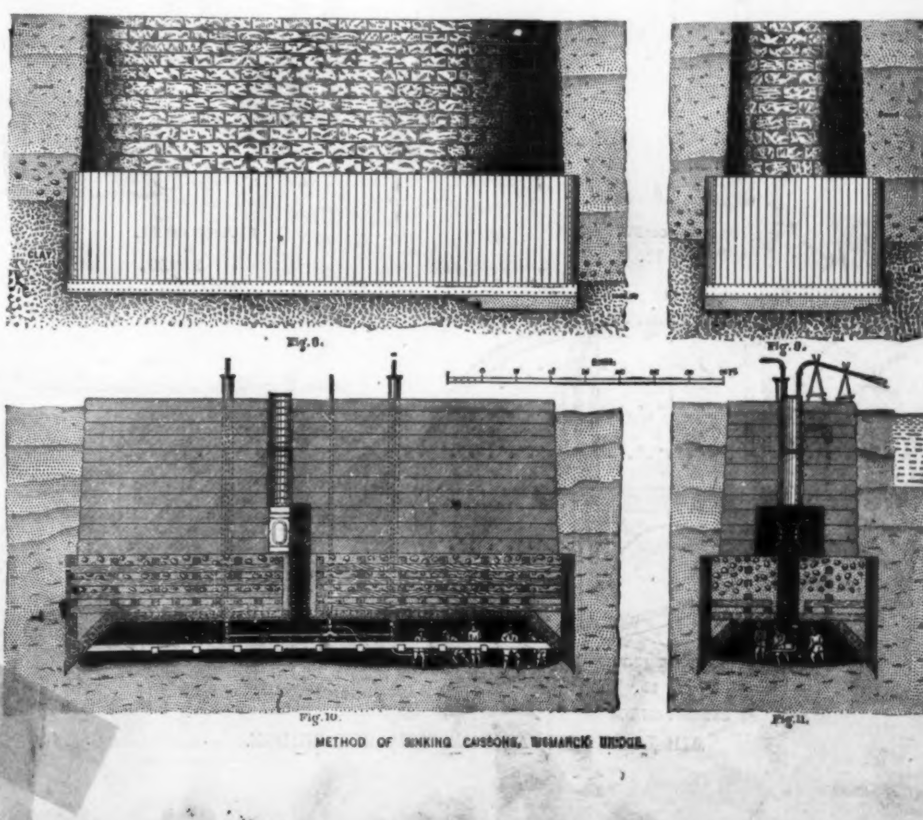


Fig. 8. Fig. 9. Fig. 10. Fig. 11.

METHOD OF SINKING CAISSONS, BISMARCK BRIDGE.

circular chambers had doors opening into both of the intermediate spaces; it was, in fact, a double air lock, each chamber forming an entirely independent lock by itself, but using the same shafts for access to the air locks and from the air locks to the caisson. The air lock was placed on the top of the caisson and built into the lower courses of the masonry; in this position it was absolutely protected from injury by the mass of masonry in which it was buried, and also at a safe distance above the working chamber.

When the work was completed the shell of the lock was left below in the masonry, the doors and all fitting being removed.

The excavation at the site of pier IV. was begun Sept. 15, 1881, but carried on slowly. Pile driving was begun Nov. 26, and completed Dec. 27. The laying of masonry was begun in January, 1882, and the pier was finished May 12. The quantities of masonry in the Bismarck Bridge are as follows:

	Masonry.	Concrete.	Total.
East Abu't.....	70 cu. yds.	23 cu. yds.	93 cu. yds.
Pier I.........	952 "	779 "	1,731 "
Pier II	2,705 "	847 "	3,552 "
Pier III.......	2,653 "	860 "	3,513 "
Pier IV.......	1,090 "	264 "	1,354 "
Totals.........	7,470 cu. yds.	2,773 cu. yds.	10,243 cu. yds.

There have been used in the masonry of the Bismarck Bridge more than 7,500 barrels of imported Portland cement and over 3,000 barrels of American cement. Nearly all the concrete was made with Portland cement, which was also used for the face stone of the masonry and for the backing in very cold weather.

The use of Portland cement mortar, salted whenever necessary, combined with the mildness of the winter, rendered it possible to lay masonry with little interruption through the whole season.

A large portion of the masonry of piers II. and III. was laid with a derrick boat. This derrick boat was designed by Mr. Thomas Saulspaugh, one of the contractors. It consisted simply of a large scow on which was erected a timber bent which was stayed in both directions. In front of this bent was placed an ordinary boom derrick of precisely the same class used on land, which was guyed to the bent by a pair of timbers reaching from the top of the mast to each end of the cap.

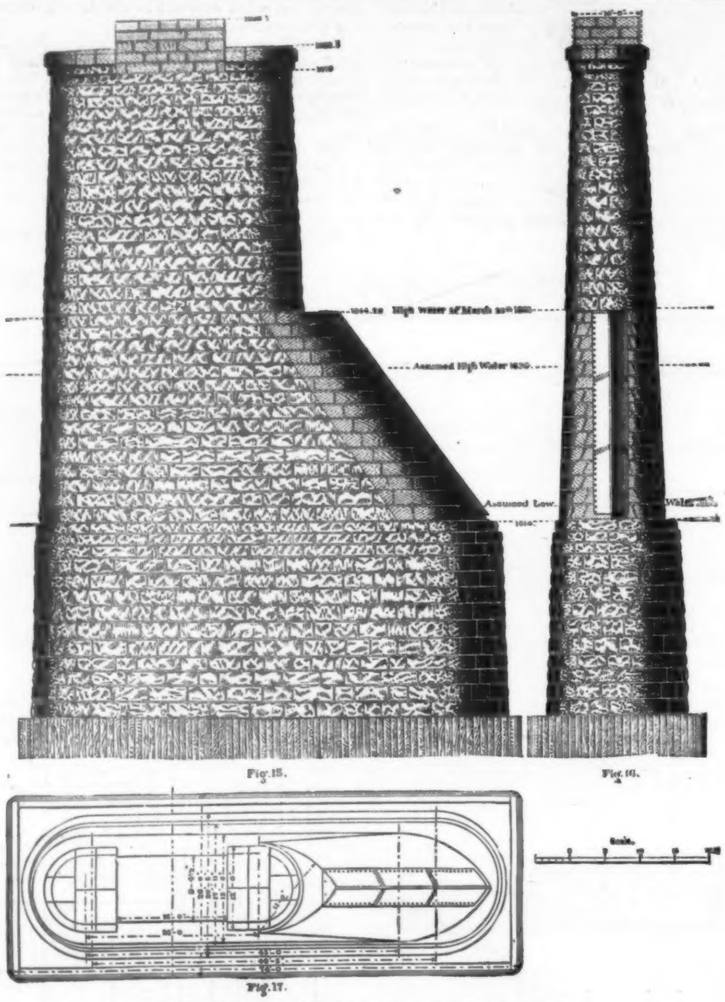
ICE PROTECTION.

The Bismarck Bridge is the first bridge which has been built across that portion of the Missouri River which is subject to ice gorges, and the question has been raised as to the effect of the bridge on the movement of ice.

The piers are of unusual size, with long raking ice-breakers shod with steel. They are at once of such a shape as to cut readily the largest sheets of ice, with whose movement the breaking up begins, and to afford the least possible obstruction to the moving mass of broken ice which follows the first shove. Their stability far exceeds any force which the ice can possibly exert. As to the effects upon the movements of the ice, experience can only prove whether gorges will occur more frequently or less frequently at the bridge site than elsewhere. But since the contraction of the river bed has been accompanied by an increased depth of channel, it is not expected that gorges at the bridge will be much more frequent than elsewhere.

APPROACHES TO THE BRIDGE.

The east approach to the Bismarck Bridge leaves the old main line at Bismarck station, and is exactly two miles long. It differs in no essential respects from other portions of the Northern Pacific Railroad through this section of the country, except that some heavy work and sharp curvature is encountered on the face of the bluffs adjoining the bridge.



MASONRY OF PIER III., BISMARCK BRIDGE.

The west approach is 6,000 ft. long from the west end of the permanent bridge to the old track on the low bottom land between the river and Mandan. This approach has a grade of 1 per cent. (52·8 feet per mile), descending westward. The eastern 1,500 feet of the west approach is built across the space reclaimed from the Missouri River by the action of the dike, which is now a sandbar already covered with a fair growth of willows. This part of the approach consists of a timber trestle, the maximum height of which is about 60 feet. This trestle spans the main steamboat channel of 1880, which is now a willow swamp. To protect this trestle from destruction by ice, another large embankment is now being built on the upstream side of the trestle, which will be finished 6 feet higher than the great flood of March 30, 1881. The embankment will stop the flow of ice which may be carried over the top of the dike. It is designed ultimately to fill the timber trestle with earth, and the protection embankment is so located that it will form a portion of the final filling.

The remainder of the west approach consists of an earth embankment having a maximum height of 43 ft., which runs out to nothing at the west end.

ICE GORGES.

Gorges are liable to occur at any point on this portion of the Missouri, and the effect of these gorges is to form a complete dam across the channel of the river. When such a dam is formed, the only outlet for the discharge of the Missouri is over the frozen bottom land. The track across the low bottom land between Mandan and the river is 10 ft. below the high water of 1881, and this low bottom land is regarded as a safety-valve through which the discharge of the river can pass in case an ice gorge is formed at or near the bridge.

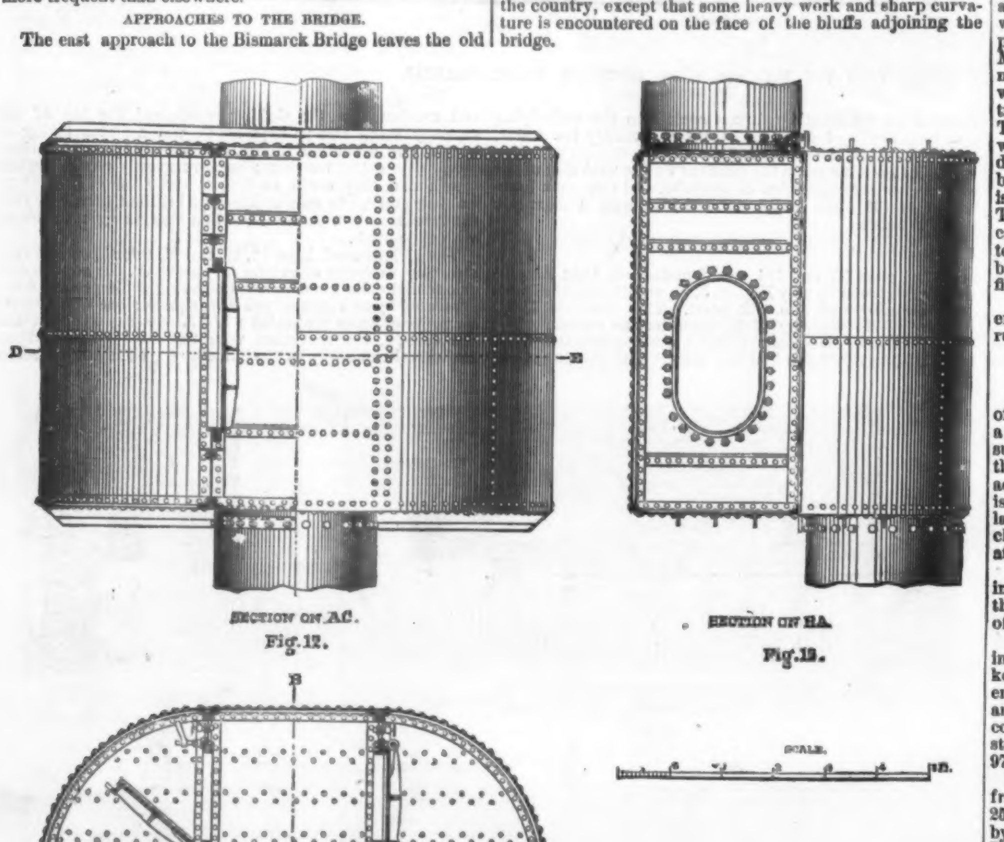
When experience has shown just what is required, an inexpensive bridge can be built, if found necessary, across this low bottom land and the track raised above the danger of overflow.

The approach spans are deck trusses of the fish-bellied or inverted bow-string pattern, this form being adopted to keep away from the slope of the embankment. They are entirely of wrought iron, except the pins, which are of steel, and the wall plates, which are of cast-iron. Each span contains 88,954 pounds of wrought-iron, 2,825 pounds of steel, and 5,686 pounds of cast iron, the total weight being 97,515 pounds.

Each of the three main channel spans measures 400 feet from center to center of end pins divided into 16 panels of 25 feet each. One of these spans is represented in detail by Figs. 19 and 20. The trusses are of the double system Pratt or Whipple type, are 50 feet deep from center to center of chords, and spaced 22 feet apart between centers. The pedestals, the end posts, top chords, the ten center panels of the bottom chord, and all the pins and expansion rollers are of steel. All other parts are of wrought iron, except the filling rings, wall plates, and ornamental work, which are of cast iron.

Each span contains 600,950 pounds of wrought iron, 348,797 pounds of steel, and 25,779 pounds of cast iron, the total weight of each span being 975,524 pounds.

The steel was manufactured in an open-hearth furnace, and under the most rigid inspection. It is of such character that small sample bars were bent double and flattened back on themselves without any crack on the outside; one of the full sized bars intended for the bridge, when tested to breaking, was stretched 4 feet in 25 before fracture took place. The long spans are proportioned to carry two 75-ton loco-



AIR LOCK USED AT THE BISMARCK BRIDGE.

motives followed by a train of 30-foot cars, each loaded with 20 tons. With this assumed moving load the strains on the different parts of the structure are about 10 to 20 per cent. less per square inch than the limits which good practice has sanctioned in many other bridges.

The manufacture of the steel proved a source of serious delay, as the parties who originally undertook to furnish it wholly failed in doing so. Had the superstructure been promptly manufactured, the bridge could have been opened at least two months earlier than it was. The floor is placed above the bottom chord, the floor beams being riveted to the vertical posts, thus increasing the vertical stiffness of the structure, and reducing the apparent height to about 45 feet. The main and counter ties, which are more than 70 feet long, are made in two lengths and coupled on a pin which passes through the center of each vertical post, this arrangement at once sustaining the tie from deflection and holding the post against flexure at the center. The end posts are stiffened by a strut connecting them at the center with the stiff center of the first vertical post. The vertical posts are connected transversely at the center by struts which are attached to the central pins by small pins, which pass through the ends of the strut and through the main pins and serve also for the connection of a set of transverse diagonal rods reaching to the top lateral system; each pair of vertical posts is thus united into a stiff bent with a perfect system of bracing from the center up, and a stiff base made by the floor beam connection. The end posts are made proportionately stiff by a wrought iron portal above the center, the sides of which are extended down the sides.

The floor is formed of oak timbers 9 inches square and 15 feet long, spaced only 6 inches apart in the clear. On this are laid the steel rails of the track, inside of which are placed angle irons bolted to every tie in a manner which is believed to make the floor perfectly safe from accidents due to derailment.

The extreme height from the bottom of the deepest foundation to the top chord of the bridge is 170 feet. Every precaution has been taken to provide for the special strains due to the violent gales which at times prevail in the Missouri valley.

ERECTION OF THE SUPERSTRUCTURE.

The east approach span was erected in April, and the west approach span in May.

The erection of the long spans was postponed until after the summer flood. Each span was subdivided into three spans of about 130 feet each by two timber piers, which supported Howe trusses of design similar to those commonly used on railroads. On these Howe trusses was placed a floor 30 feet wide, on which ran a traveling derrick 65 feet high, which spanned the permanent structure. This derrick was moved from panel to panel, as the work proceeded, and the great trusses were erected without any stationary staging above the floor. All the hoisting was done by steam, the engines being mounted on a low flat car entirely independent of the traveler.

The first span erected was that between piers I. and II. The first iron was placed on Thursday, July 27, 1882, and the span was swung off so as to carry its own weight on Saturday, August 12. Exactly four weeks later, on Saturday, September 9, the second span, that between piers II. and III., was swung, and four weeks after that, on Saturday, October 7, the last span carried its own weight, requiring only the addition of the floor and the riveting of some of the details to make the bridge complete.

GENERAL REMARKS.

The Bismarck Bridge and approaches form an integral part of the Northern Pacific Railroad, being the absolute property of the Northern Pacific Railroad Co., and being built under the general charter granted by the National Government to that company.

The personnel of the Bismarck Bridge during construction was as follows:

George S. Morison, Engineer and Superintendent.

Resident Assistants—Henry W. Parkhurst, First Assistant Engineer; Benjamin L. Crosby, Assistant Engineer; Geo. A. Lederle, Assistant Engineer and Draughtsman.

Non-resident Assistants—C. C. Schneider, Assistant Engineer of superstructure; William F. Zimmerman, Inspector of steel and iron; James Sanderson, Inspector of shop work.

Local Inspectors—B. A. Sawyer, Inspector of stone at quarries; Robert Ross, Inspector of masonry.

The contractors for the work were as follows:

Sub-structure—Saulspaugh & Co., general contractors for sub-structure. Rust & Coolidge, sub-contractors for pneumatic work.

Superstructure—Detroit Bridge and Iron Works.

Grading approaches—Bellows, Fogarty & Co.

Timber trestle—Winston Brothers.

Riprap stone—C. W. Thompson.

HOW TO MAKE CONCRETE WALLS.

CONCRETE walls are not a necessity, but they are by general consent regarded as the cheapest of the more durable walls, and also have the great advantage of requiring the attendance of no skilled workman—or at any rate but one—while the regular laborers of the farm can be employed on the work at a manifest saving of outlay. If cobble or flat stones—of two to ten or even thirty pounds weight—are plenty on the farm, and sand can be obtained near by, then the conditions for the cheapest construction are present. American cement (hydraulic cement), of which the Rosendale is most prominent near New York, can be used. But Mr. Cocroft, who was the experimenter for Gen. Gillmore in his investigations of cements, concrete, and artificial stone, thought the imported cement known as "Portland" very much stronger, more uniform, and decidedly preferable for this purpose. The sand should be sharp and reasonably dry. The concrete can be readily made by any Yankee. Provide a mortar bed, of thirteen foot boards laid on level ground, say thirteen feet wide, put up a board on edge on one side and one end, leaving the others unprotected. Now pour on one end of the bed four barrels (cement barrels) of sand, and into or on the heap one barrel of cement, fine and free from hard lumps; let two men with shovels turn this heap over four times. Next, put near it on the mortar bed a heap of gravel, free from sand if possible, and preferably of stones the size of peas or beans. Let two or more men shovel these heaps together, then turn them over four times. Caution: First, last and always, be sure that no particle of loam or earth gets into the sand or other materials, for, as the cement men say, "it kills the cement."

Now the gravel and sand with cement having been thoroughly mixed while dry and in the above proportions, let two men turn the combined heap again four times, while a third sprinkles the mixture, as it leaves the shovels, with water from the rose or sprinkler of a watering pot. It is not safe to venture to wet the material, without the sprinkler. Of course the material, after having been mixed dry, should be kept from getting wet until the moulds are ready, so that when wet it can be deposited in place immediately. Once in its moulds, and tamped to drive out all air and prevent blow holes, it should be left entirely undisturbed thereafter. Each jar afterward greatly interferes with its strength. If stones are at hand, clean and free from loam, they can be wet—be sure of this—and bedded in the soft mortar, not only without detriment but with positive advantage to the wall. They occupy space that must otherwise be filled with cement, and so greatly reduce the cost of the wall. In wetting the mass it is best to wet a pile of the dry material not larger than say a barrelful at once, and send it to the wall as soon as mixed, and to mix another like mass while the first is being carried.

After a trial of several plans, it proved by far most economical to carry the mud in hods rather than in boxes, and it will pay to hire one or two hod carriers. Again, while the mass can be too wet, it is more likely to be put in too dry than too wet. A thin rather than a stiff mortar is the rule. The books advise going once round the wall each day, raising the wall say one foot to twenty inches. It is clear to me that it would be better to have a second set of moulds, and to leave the wall to harden in its moulds at least forty-eight hours before they are removed. The wall will certainly be stronger for so doing, and the workmen can proceed with much greater celerity if they have no fear of injuring the work of the preceding day. After a little time it is as hard as brick work and as little likely to crumble.

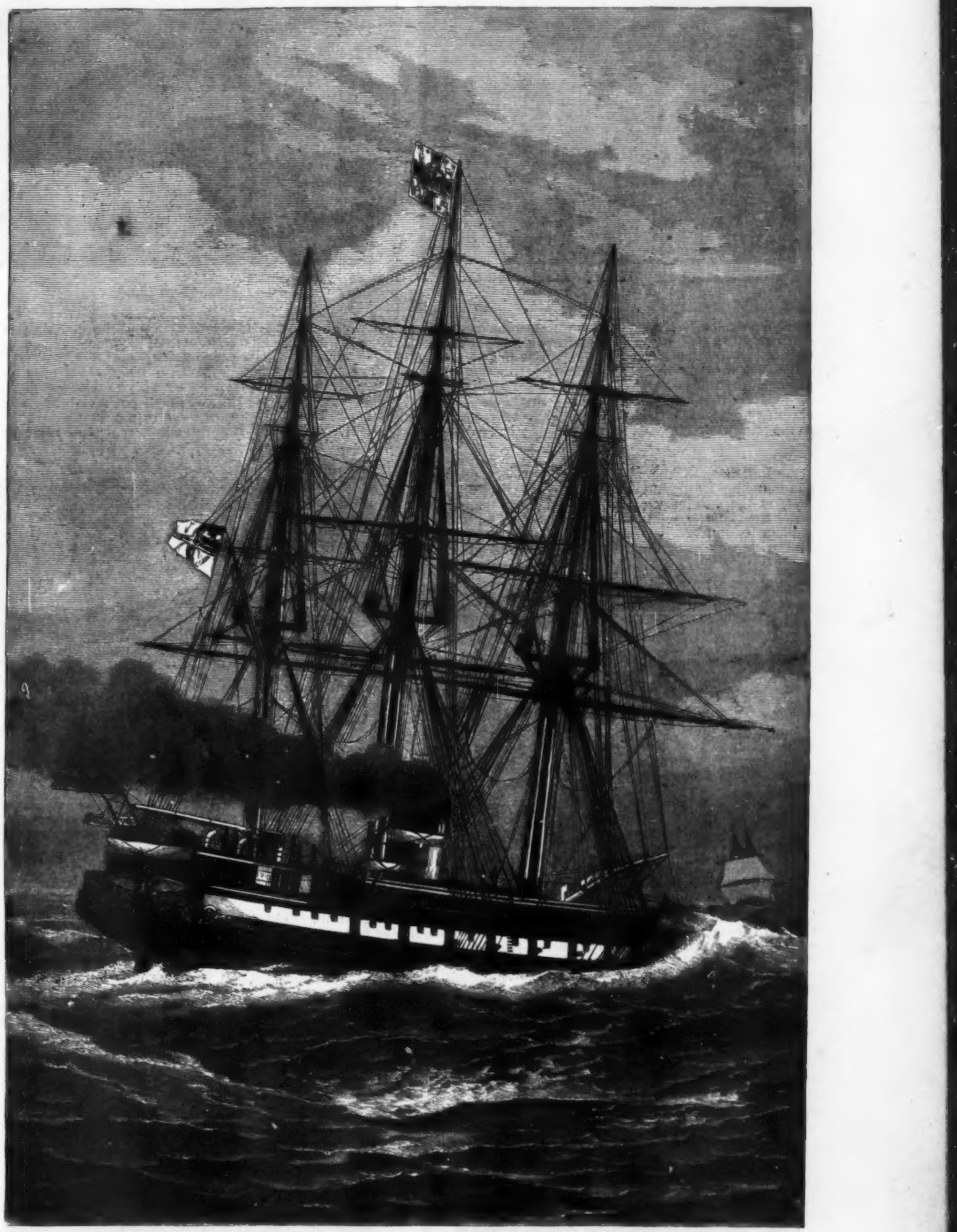
For the ordinary silo walls, 16 to 18 inches thick is probably about right.

If the materials are carefully mixed and tamped after being put in very liquid, success is assured. The concrete should not be made in weather severely cold. Temperature 70° Fahr. is about the best.

THE GERMAN CORVETTE PRINCE ADALBERT.

THE annexed cut, taken from the *Illustrirte Zeitung*, shows the German corvette, Prince Adalbert, which conveyed the German Crown Prince Frederick William from Genoa to Valencia on his voyage to Spain.

The Prince Adalbert is the flag-ship of the squadron composed of the corvettes Leipzig and Sophie and the dispatch boat Lorelei. The Leipzig and the Prince Adalbert are the largest corvettes in the German navy. The Prince Adalbert belongs to the class of cruisers and is not armored, so as to enable it to attain the greatest possible speed. It is also provided with full rigging, so that sails can be used to great advantage. The armament of the Prince Adalbert consists of ten 6½ inch guns, several bronze cannons to be used in landing troops, torpedoes, and a series of five barreled Hotchkiss revolving cannons for firing grenades and shells. The displacement of the vessel is 4,000 tons, and its draught 20 ft.; it has a 4,800 horse-power engine, and a crew of five hundred, all told.



THE GERMAN CORVETTE PRINCE ADALBERT.

POOR ECONOMY.

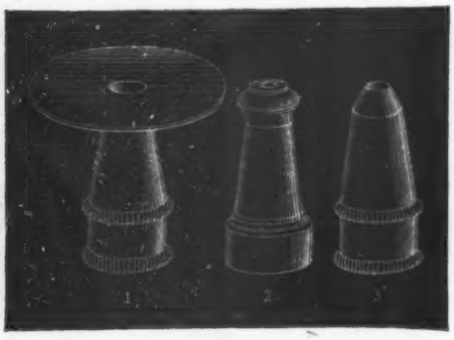
A FAVORITE method of saving, especially among managers of small establishments running only a small engine, is to employ no engineer or fireman, some apprentice or other incompetent managing boiler and engine. One establishment of this sort has lately had an illustration of the folly of this economy. A good engine and a new boiler were put in less than one year ago, and the proprietors were advised by the mechanic who superintended the job to get a competent man to manage them. But nothing seemed easier than to keep up a fire, feed water, oil up, and start and stop an engine. Lately the establishment has been stopped for repairs; boiler tubes have been drawn and replaced, a new crown sheet has been patched in, and the grate has been renewed—burned out from the accumulation of ashes in the ash pit. Added to this a new seating of the valves was necessary from lack of lubrication. The cost of repairs would have gone far toward paying for a proper man.

IMITATION OF THE PHENOMENA OF ELECTRICITY AND MAGNETISM BY LIQUID OR GASEOUS CURRENTS.*

Is electricity a peculiar fluid, single or double, as it is usually said to be? Is it a mode of motion of the universal ether, or of ponderable matter, or of both? Is such motion undulatory or vibratory? This is something that cannot be decided in the present state of science.

The problem has, however, been attacked many times from different sides by learned mathematicians and by numerous and skillful experimenters, but no definite solution has as yet resulted from these laborious researches.

I could not possibly have the pretension to decide so delicate and so controverted a question; but I shall offer in support of one of the hypotheses to which I have just



FIGS. 1 TO 3.

alluded a demonstrative collection of numerous experiments that establish a striking analogy between electric or magnetic phenomena and the effects that I obtain by the aid of liquid or gaseous currents—effects which extend to the different principal parts of electricity, and which are to be examined successively from the standpoints of mechanics, physics, chemistry, and even of physiology, while confining myself to the purely experimental side of the question.

MECHANICAL EFFECTS.

1. Imitation of the phenomena of electro-magnetism and induction by liquid currents.

If, at the extremity of a sprinkling-pipe, supplied by water from the city mains, we adapt a disk 0·07 m. to 0·08 m. in diameter and on a level with the aperture, and bring this disk within a few millimeters of a pavement or the flat

FIGS. 4 TO 6.

bottom of some vessel, the pipe, as soon as the liquid begins to pass through it, will be *attracted* toward the obstacle with an energy that will depend upon the force of the current and the diameter of the disk. The attraction does not bring the disk into contact with the opposing surface, but, when we desire to raise the pipe, we experience quite a resistance, due to the difference in pressure that is exerted on the one hand upon the disk, and on the other upon the liquid in the interval.

Continuous Current Hydro-Magnet.—The experiment which precedes is the image of an *electro magnet* that remains active so long as the electric current lasts, and which ceases immediately with it. On substituting for the disk a nozzle provided with a disk (Fig. 1) and screwed to the extremity

FIGS. 7 TO 11.

of the pipe, or a nozzle with edges 0·003 m. to 0·004 m. thick (Fig. 2), we again have an attraction. But if we substitute a nozzle having a sharp or simply a thin edge, 0·001 m. to 0·002 m. in thickness, and cylindrical or conical (Figs. 3, 4, and 5), the attraction changes to *repulsion*—a fact without analogy among the phenomena of electro-magnetism.

The effects of attraction or repulsion are stronger with converging nozzles than with cylindrical ones, and more marked with these latter than with diverging ones.

From these effects we can see how we may produce a hydro-magnet with two contrary poles, one attractive and the other repulsive, or with two poles of the same name.

Discontinuous Current Hydro-Magnet; Hydrodynamic Vibrations.—The arrangements being the same as for a continuous current hydro-magnet, the nozzle having thick edges and the aperture being very near the fixed plane, if we raise the pipe a little to start a flow, and then leave it to itself, it will spontaneously undergo vertical vibrations which are sufficiently rapid to produce a regular sound. This effect is analogous to that of an *electro-magnet* placed under the influence of an automatically interrupted current, as in electrical vibrating bells. When this vibrating tube is held in the hand, we might be led to think that we were dealing with a true electro-magnet, so rapid and strong are the successive effects of attraction and repulsion, these being

FIGS. 12 TO 15.

exactly like those of magnetization and demagnetization as regards their instantaneousness and the increase in action in measure as the distance diminishes.

The vibratory motion likewise takes place even more energetically, but by repulsion, with nozzles having thin edges. According to this, we may form a vibrating hydro-magnet having *two contrary poles*, or a *double acting* apparatus, by using two slightly convergent and thin edged nozzles.

FIG. 16.

Again, we might, to complete the imitation, give the tube the form of a horse shoe magnet whose two extremities were provided with equal nozzles. But, on thus dividing the same current into two equal parts, the total effect would be inferior to that obtained from a single current. Such a division is no less unfavorable for water than for electricity.

This experiment, with the simple or the double apparatus, is not only an abstract imitation of the electro-magnetic

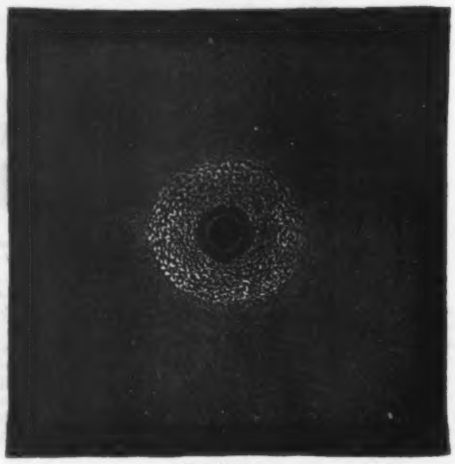


FIG. 16 *bis*.

phenomenon, but is an effective realization, like the motions produced by electro-magnets under the influence of a regularly interrupted current. It even appears to me susceptible of receiving dynamic applications. It is easy, in fact, to imagine mechanical arrangements that would make of this hydrodynamically vibrating tube a small high-speed motor, an interrupter, a commutator, or a counter.

Hydro-Induction.—In the preceding vibratory motions, the simple phenomenon which is the determining cause of them is the one that is produced in a tube at the moment of the *interruption* and *passage* of the liquid current, the extremity of the open tube being far from any obstacle. At the moment at which the cock is *suddenly opened* that gives passage to the liquid, there is felt in the tube as it is held in the hand a very pronounced *recoil* motion; and, when the cock is closed quickly, we feel, on the contrary, a motion that carries the tube *forward*. Of these effects the first is analogous to that of the hydraulic tourniquet, and the second to the hydraulic ram-stroke that is produced by the sudden stoppage of a long internal liquid column. On compar-

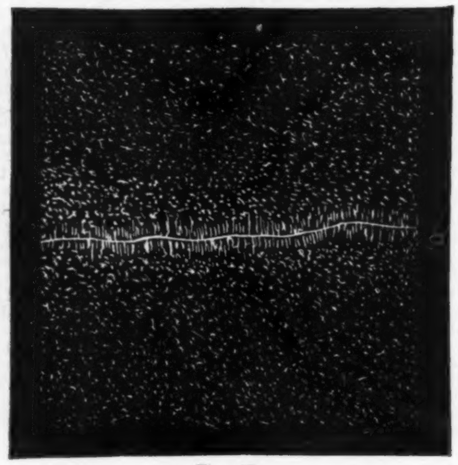


FIG. 17.

ing the liquid current with an *inducing* voltaic one, and the envelope (the tube) with the *induced* wire that surrounds the inducting one, the phenomena just described are found to be analogous to those that an electric current, alternately opened and closed, produces in an induced wire. Moreover, the hydrodynamic motions are instantaneous like induced currents, that is to say, they manifest themselves only at the very moment at which the current passes or is interrupted; and during its whole duration there is no dynamic

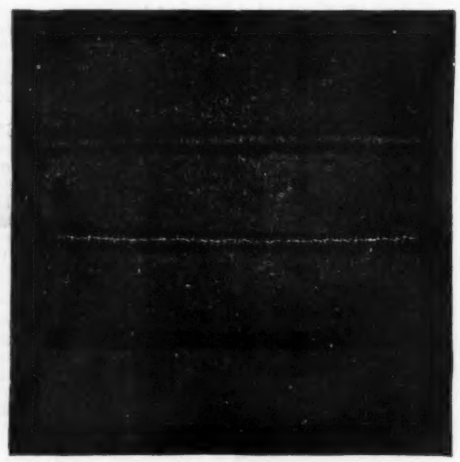


FIG. 17 *bis*.

effect. On another hand, we know that when an inducing electric current *begins*, *increases*, *diminishes*, or *ceases*, it brings about in the induced wire a *reverse*, *increasing*, *decreasing*, or direct current. It is absolutely the same with liquid currents, as may be easily verified.

2. Imitation, through liquid currents, of the reciprocal action of electrical currents.

FIG. 18.

For these experiments, I have adopted the following arrangement: To a forked nozzle (Fig. 6), which is screwed directly to the sprinkling-pipe, are fixed two rubber tubes of the same diameter and length, to whose extremities are fitted the different nozzles shown in Figs. 7 to 15. One at least of these tubes is supposed to be movable.

For liquid currents issuing (in the air or water) through two tubes *without nozzles*, parallel currents of the same or opposite direction, angular currents, etc., I have found the laws to be the same as for electrical ones. But with tubes provided with *thick-edged nozzles* (Figs. 7, 8, and 9) or *disks*

* C. Decharme, in *La Lumière Electrique*.

(Fig. 15) the results are entirely different. Two currents of exactly opposite direction *attract one another* strongly (in water) as soon as the distance that separates the apertures becomes only about a centimeter; and such attraction very rapidly increases in measure as the distance diminishes. If we try to separate the disks, we perceive quite a resistance, and there are strong *vibrations*, especially with convergent nozzles. If we arrange the nozzles *angularly* or *eccentrically*, an axial force brings back the currents to a parallelism and

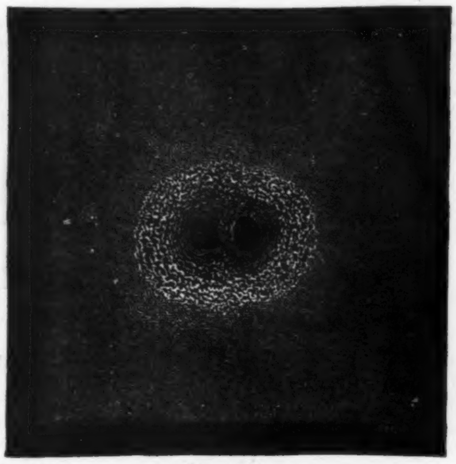


FIG. 18 *bis*.

to a coincidence of their axes. It is upon these facts that is based the construction of *hydrodiapasons*. With thin or sharp-edged nozzles (Figs. 10, 11, and 12) there is always a *repulsion*, an *axial direction*, and *vibrations*. With such nozzles, as soon as the directly opposite currents are removed from their position of equilibrium, they *oscillate* just as a compass needle does when a magnetized bar is presented before it. The lighter the nozzles and the more flexible the tubes are, the more apparent becomes the oscillatory phenomenon. When

FIG. 19.

we employ in these experiments nozzles with *curved*, *convex*, or *concave* edges (Figs. 13 and 14), we obtain effects that are quite varied.

With two equal, *concave* nozzles (Fig. 14), each terminating in a hemispherical cup, we find in the currents (one of which, at least, is movable) a perceptible *axial direction*, in the water, at a distance of more than 0·10 m., while at the same time there occurs quite a strong repulsion of the two

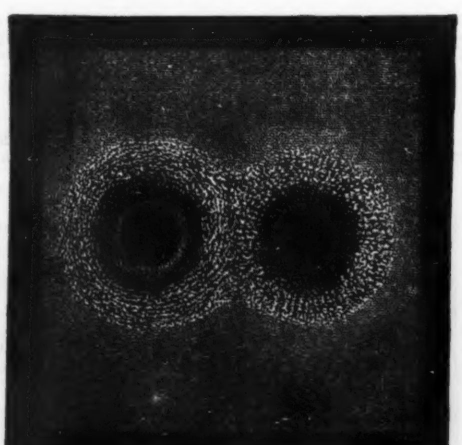


FIG. 19 *bis*.

nozzles, that is to say, of the two currents that are exactly opposed to one another.

With two analogous *convex* nozzles (Fig. 13), there is always a *repulsion* and *axial direction*. Upon putting a *concave* nozzle on one of the tubes and a *convex* one on the other, there occurs a strong *attraction* at a short distance, and one that is already perceptible at 0·05 m. The axial direction is likewise very pronounced with this system. Upon combining these nozzles of curved form with the preceding, we always find a *repulsion* when one of the latter has thin edges, and an *attraction* when it has thick ones or is provided with a disk. In all cases there is an *axial direction* with more or less pronounced *vibrations*. It is the *concave* nozzle that, when combined with a nozzle of any form whatever, gives the maximum effect.

3. Imitation, through a liquid current, of the repulsion of the consecutive parts of the same electric current; and spontaneous vibrations of a liquid current, with or without rotation.

Different experiments are known whose object is to de-

FIG. 20.

monstrate that the consecutive portions of the same electric current repel each other. We can realize analogous ones for *liquid currents*. There is one that is extremely simple and demonstrative, which I perform in the following way: A small rubber tube, very flexible although resistant (0·12 m. to 0·25 m. in length, 0·004 m. to 0·005 m., in internal diameter, and 0·0015 m. to 0·002 m. in thickness), is fitted directly to a pipe that is supplied by the city mains, or to a branch

FIG. 20 *bis*.

screwed to such pipe. When a current of water flows through this small tube (whose free extremity is held in the hand) we feel a strong *reaction* in it—a very pronounced *recoil*.

To estimate the extent of this force, we attach to the free extremity of the small tube, held vertically, a thread carrying a weight. We find that, under such conditions, this reaction is capable of lifting 140 grammes, and that it easily

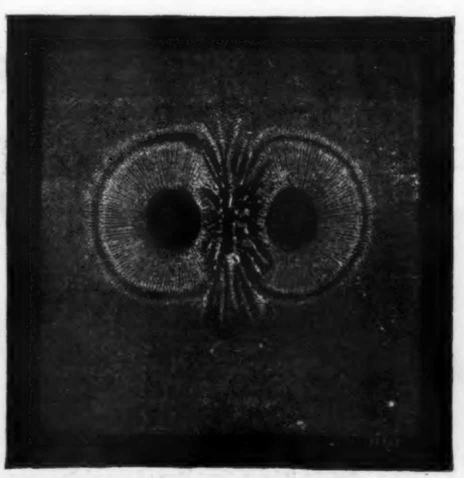


FIG. 21.

jerks up a weight of 100 grammes. If we happen to free the tube it twists in different directions and ejects water on all sides. Placed in the liquid, it squirms about therein in a lively manner just as an eel would that was held by the head. It tends, moreover, to rest on the bottom and against the sides of the vessel.

Upon using a finer and more flexible tube, 0·001 m. in thickness, the phenomenon of reaction is still more marked. As soon as such a tube is touched at one of these points, it immediately curves at this place and presses against the hand, and one cannot rid himself of it very readily without the use of moisture. On increasing the length of the tube, the motions necessarily become slower, because of the difficulty experienced by the liquid in traversing so long a channel. If, on the contrary, the tube be reduced to 0·10 m. or 0·12 m., another phenomenon occurs, the tube beginning to *vibrate spontaneously* with a speed and amplitude that are so much the greater in proportion as the current is stronger. There often occurs along with the regular plane vibrations

FIG. 22 *a*

a *rotary* motion, relatively slow, of about one revolution in four seconds. The tube at every half-revolution untwists and pursues its uniform motion in the same direction—an effect doubtless due to the naturally slightly curved form of the tube, and, consequently, to its unequal flexibility in different directions.

FIG. 22 *b*.

The preceding motions likewise occur in water, but with less energy.

All these varied effects are evidently due to the repulsion of the different consecutive parts of the same liquid current; and they well show the existence of this reaction and give the measure of it.

PHYSICAL EFFECTS.

1. Imitation, through liquid or gaseous currents, of the

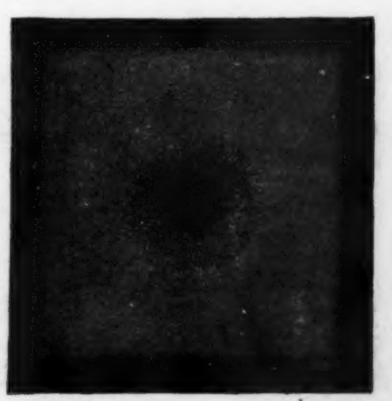


FIG. 23.

lines of force or magnetic phantoms obtained with electric currents or magnets.

The circumstances are here very numerous. We shall cite a few of them:

1. *To imitate by hydrodynamic way the lines of force of an electric current in a plane perpendicular to its direction* (Fig. 16), it is only necessary to blow gently, through a tapering glass tube, a continuous current of water perpendicularly to a plate of glass covered with a thin layer of red lead mixed with water, the point of the tube being fixed at a few

millimeters from the plate. We thus obtain around the point at which the liquid falls quite a large number of concentric circles formed of particles of red lead juxtaposed after the fashion of iron filings when under the influence of an electric current (Fig. 16 bis).

Instead of red lead we may employ very fine iron powder (iron by hydrogen), and obtain the same effects; but what we gain in analogy we lose in fineness of details.

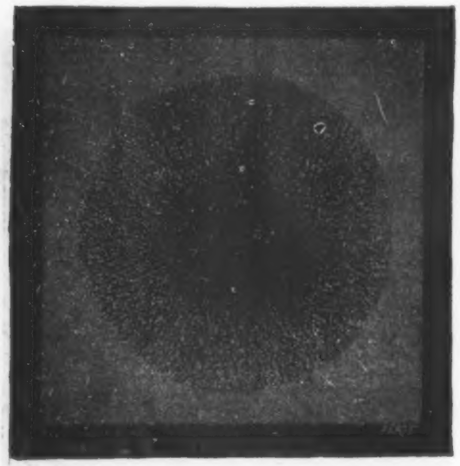


FIG. 24.

2. *To obtain lines of force imitating those of an electric current in a plane parallel with its direction* (Fig. 17), it becomes necessary to employ a current of air instead of one of water. We blow upon the deposit of red lead though a tapering tube held vertically, and during this time move the tube rapidly over the glass and parallel with it, or, so to speak, spread out the current horizontally. We thus obtain on the deposit very short, close, straight lines which are perpendicular to the current's direction and like those given by an electric current when sent over a sheet of white paper cover-

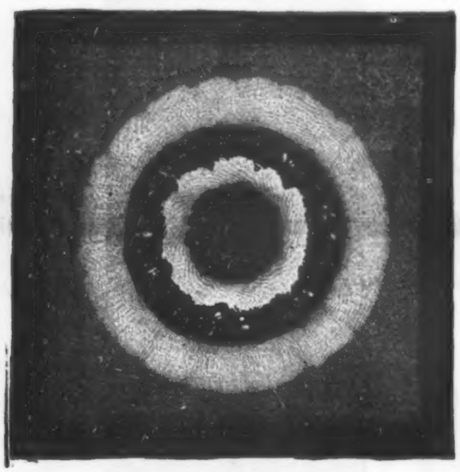


FIG. 25.

ed with iron filings (Fig. 17 bis). We can also obtain analogous effects by sucking through a tube that we are moving rapidly in contact with the plate.

3. *To imitate the lines of force of two parallel electric currents of the same direction, a plane perpendicular to their direction* (Fig. 18), we employ two tapering tubes containing water, and into which we simultaneously blow, and which we soon close before the liquid contained in each of them is exhausted. We thus obtain two systems of curves which

FIG. 26.

straighten out on meeting and repel each other (Fig. 18 bis), as occurs with iron filings under the action of two electric currents (Fig. 18).

4. *The imitation of the lines of force of two parallel electric currents of contrary directions, in a plane perpendicular to their direction* (Fig. 19) presents same difficulty. Some practical means must be found of producing effects of polarity by hydrodynamic way. Among the processes that I have devised, I shall cite the following: I make use of two glass tubes, one of them tapering for projecting the fluid through the compression of a rubber ball adapted to it, and the other, not so narrow, serving to suck up the liquid and the red lead that the latter carries along. By a simultaneous play of the two tubes, properly placed, one of them at a few millimeters from the plate, and the other in contact with the layer of powder, we produce a figure which plainly shows the two effects of opposite polarity (Fig. 19 bis). We

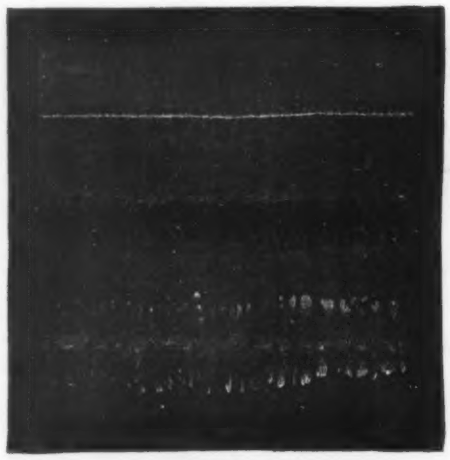


FIG. 26 *bis*.

shall see further along that the *suction* appears to correspond to *positive* and *blowing* to *negative* electricity.

For the imitation of the large magnetic phantoms that are produced by isolated or combined magnets, under conditions that correspond to those of the currents that have just been considered, we employ means that differ little from those that precede, and non-tapering tubes.

Fig. 20 bis represents the hydraulic imitation of a magnetic phantom (Fig. 20). Fig. 21 gives the hydraulic imitation of the magnetic phantom of two contiguous and parallel

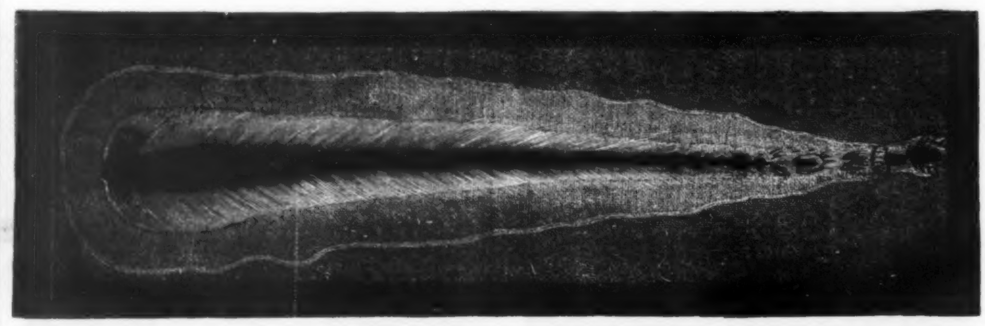


FIG. 27 *a*.

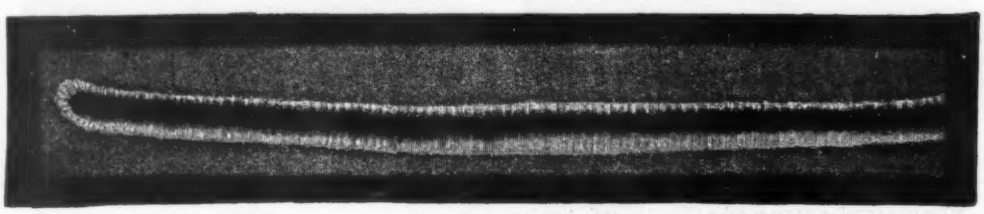


FIG. 27 *b*.

magnets, of like poles, in a plane perpendicular to the direction of their axes.

We may thus produce varied effects by hydrodynamic way, either by a free fall of liquid columns of different lengths, or by sucking or blowing liquids or currents of air, these effects being so many imitations of the numerous sorts of magnetic phantoms that are known or are capable of being produced.

2. Imitation of the forms and effects of the electric discharge.

An imitation of electric brushes and flocci (Figs. 22, *a*, *b*), and of rectilinear, ramified, and sinuous electric sparks, may

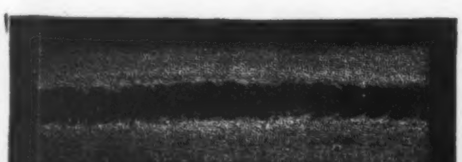


FIG. 27 *c*.

be easily obtained, either by blowing a current of air or water with a tapering tube in the plane of the plate covered with red lead and water, or by moving the tube parallel with the plate. The starry spark is exactly imitated by Fig. 23, which was obtained by sucking up strongly with a fixed pipette the half-dried red lead.

The imitation of Lichtenberg's figures presents the peculiarity that the effect of *suction* corresponds to *positive electricity* (Fig. 24) and *blowing* to *negative* (Fig. 25)—a fact which may have its importance.

Imitation of the projections of a wire volatilized by an electric discharge.—If, by means of a tapering tube brought to within about 0·01 m. of the red-lead-covered plate, we direct a current of air upon the latter, moving the tube horizontally at the same time, there will be produced a narrow furrow, a part of the material will float to the surface of the mixture of red lead and water, and the subjacent and fixed material will be arranged in very fine straight lines perpendicular to the axis of the furrow (Fig. 26 bis) and similar to those that are obtained by causing an electric discharge to pass through a wire between two glass plates or between two sheets of paper (Fig. 26).

Imitation of the stratifications of the electric light in rarefied gases.—This is obtained by a process already employed in our preceding experiments. Above the plate with its layer of red lead we move a tube horizontally and quickly while water is flowing from it and we are blowing into it. The current then becomes spread out in a straight or curved line upon the pulverulent deposit. The tracings that are produced therein are often preserved with their delicate forms. To obtain certain effects we may substitute with advantage a current of air for that of water. The imitation becomes

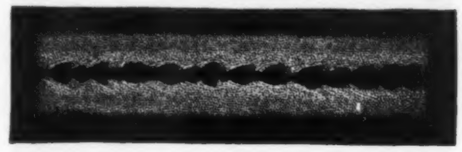


FIG. 27 *c'*.

still more exact on employing interrupted currents of air, either with a single or double tube. On varying the conditions of the experiment, we find among the designs obtained (Fig. 27, *a*, *b*, *c*, *c'*, *d*, *e*, *f*, *g*, *h*) forms analogous to those of the extremely varied stratifications of the electric light in gases rarefied to different degrees; for example, we find V-shaped ones like those that Mr. Warren de la Rue has shown in his beautiful researches in the electric discharge (*Ann. de Chim. et de Phys.*, December, 1881). We frequently meet with some, too, that are in the form of little drops analogous to the globular strata that the electric discharge gives through a tube containing carbonic acid at a pressure of 0·5 mm. (Fig. 27, *c'*).

Our hydrodynamic imitations of the stratifications of the electric light show all the degrees of the phenomena, from the continuous current without strata to the current with perceptibly separated drops, in passing through all the intermediate forms. Another process, purely mechanical, gives a very close imitation of the phenomenon of strata. This consists in covering the plate of glass with a layer of nearly dry red lead and rubbing the glass between the wet fingers, just as when we desire to excite sonorous, longitudinal vibrations in a wooden rod. From this there result strata (Fig. 27, *f*, *g*, *h*) exactly like those of the electric light in tubes containing gases in various degrees of rarefaction.

The bead flask pointed out by Mr. G. Planté may be readily imitated by moving the tube full of water rapidly over the aqueous layer of red lead, so that the drops may flow out in succession and spread out in juxtaposition over the plate (Fig 28, *a*, *b*, *c*). As for the ball flash, or globular light-

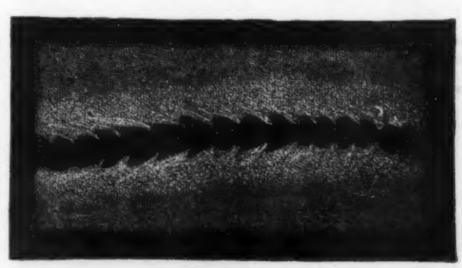


FIG. 27 *d*.

ning, we have an imitation of that in the spherical drops that sometimes roll on the surface of the liquid when they fall isolatedly through a narrow tube or are blown out.

Again, we obtain by the means that have been previously indicated forms analogous to those that Mr. Plante has described under the names of "sheaves of aqueous globules," "jets of steam," "crateriform perforations," etc. We also obtain figures whose forms have much affinity with those of tromps, polar auroras, comets' tails, etc.

As examples of different well known analogies between the two phenomena that we are comparing, we may recall

the following: The electric *tourniquet* and *moulinet*, which correspond to their hydraulic namesakes; the electric "overflow" (*trop-plein*) invented by Mr. Mascart for maintaining the constancy of a potential upon a conductor, and which is analogous to its namesake used in hydraulics. To electrophores and electric condensers and accumulators, correspond the pressure fountain and compressed air apparatus. The effects of electric volatilization have as an analogue the "pulverization" of liquids. Finally, there is the

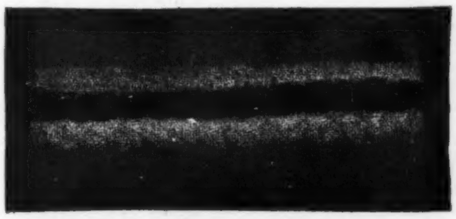


FIG. 27 *e*.

hydro-electric machine of Armstrong. It might be possible, in taking as a basis the effects of attraction and repulsion that I have just made known, to get up different apparatus analogous to Coulomb's electric balance, De la Rive's floating currents, and to electric motors, etc.

We may see from this how numerous and remarkable are the analogies between electric and hydrodynamic effects.

Projections.—All the figures that have been noticed in this place may be projected in enlarged form before an audience by means of Duboscq's projecting apparatus, either when they are already fixed or at the moment they are produced.

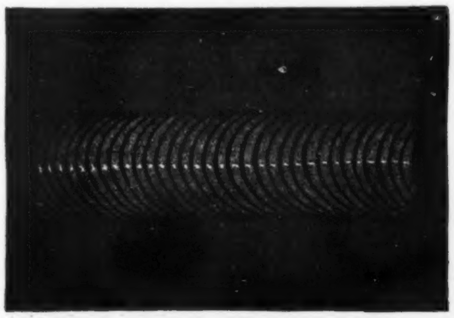


FIG. 27 *f*.

In the latter case, we have a very attractive series of extemporaneous experiments.

Photographing the Figures.—From the different plates upon which designs have been obtained negatives may be made by the usual methods. It is possible with a little care, without having recourse to varnishing the plate, to make several copies of these designs. The operation may be shortened by using the sensitive paper called ferro-prussiate. An exposure of 10 to 15 minutes in the sun, or of 30 to 60 in diffused light, will suffice to give good copies. There is nothing more

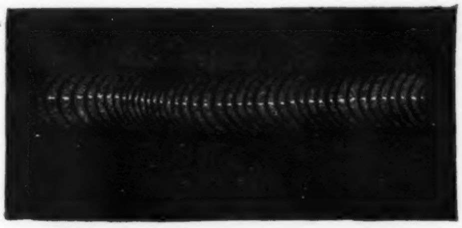


FIG. 27 *g*.

to be done then than to immerse these in water for a few moments and afterward dry them.

CHEMICAL EFFECTS.

Imitation of the electro-chemical rings of Nobili.

Of all the imitations of the effects of hydrodynamic electricity, this is the most remarkable and the most conclusive in favor of the resemblance of the electric current to a liquid one.

We know that Nobili's rings are produced by the action of an electric current coming through a platinum wire into a metallic plate covered with a thin layer of an aqueous so-

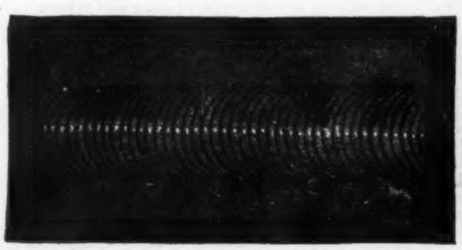


FIG. 27 *h*.

lution of acetate of lead, plumbate of potassium, or of some other salt. According to the polarity, the nature and polish of the plate, according to the solution of the different salts, simple or mixed, and according to the energy of the pile employed, we obtain upon the plate in a few seconds, opposite the vertical point brought to within a few millimeters of it, concentric rings that are sometimes monochromatic—alternately light and dark—and sometimes iridescent, like Newton's rings. And if we employ several wires connected with the same pole, we obtain rosework and various symmetrically colored figures.

These effects I have endeavored to imitate by means of liquid currents.

To obtain rings hydrodynamically that imitate those of Nobili, I have only had to follow step by step, and almost textually, so to speak, the mode of experimentation described by the Italian savant (*Annal. de Chimie et de Physique*, 3d ser., t. xxxiv., p. 280), and improved by Mr. Becquerel. It was only necessary to make the following changes:

Thus, the polished metallic plate (which might, strictly

FIG. 28 *a*.

speaking, be preserved), is replaced by a glass one; the litharge, instead of being in solution in potassa, is suspended in water,* and the tapering platinum point which gives passage to the electric current becomes here a tube of greater or less length (according to the effects to be produced), which contains a column of liquid whose length and whose height of fall correspond to the duration and energy of the electric current. I arrange the experiment, then, in the following manner:

A thin stream of liquid, falling from a graduated glass tube held vertically at a distance of 0·01 m. to 0·10 m., or more, reaches a horizontal plate of glass covered with a thin and uniform layer of red lead suspended in water. Under such conditions there is instantaneously produced on the plate, around the point of fall, concentric rings which vary in number, are unequally spaced, and of different thicknesses, and which are formed by the mechanical carriage of the pulverulent deposit under the impulsive action of the liquid current. These rings usually exhibit very sharp contours and gradations of tones remarkable for their delicacy. There are frequently distinguished therein very fine radii, that sometimes traverse all the series of rings, and form symmetrical designs which are very varied and very delicate (Fig. 29).

We may, from this, already obtain some idea of the effects common to the two phenomena. To better show this analogy, I might describe the details of the comparative experimental arrangements, and the effects obtained on the one

FIG. 28 *b*.

hand and the other; but I shall confine myself to merely a citation of the principal facts regarding the hydrodynamic rings, wherein will be readily recognized the analogies in Nobili's rings.

The sharpness, regularity, and delicacy of the rings, in a word, their beauty, depends upon the nature of the powder in suspension in water, that is to say, upon its density and fineness. The narrower the tube and the nearer it is to the plate, the finer and closer are the rings. Their number and diameter vary with the length of the column of liquid and its height of fall. There are usually four or five of them, but frequently eight or ten. All the rings of the same figure have not the same sharpness. Those nearest the center are the most regular, and have the best defined contours, while the external ring, driven to a distance, is generally devoid of sharpness, and is edged with festoons that are sometimes wanting in regularity.

Now the center is brilliant, and leaves the glass plate naked, and then again it is a roundish or star-shaped black spot. All the rings spring from one another, and are propagated *in waves*, as are those of Nobili.

We may obtain these hydrodynamic rings of all dimensions, from those 2 or 3 millimeters in diameter up to those 25 or 30 centimeters or more. But, small or large, these figures always possess analogous forms; sometimes the small ones exhibit in miniature all that can be found in the large or medium-sized ones, and then they are charming.

All this magnificent geometrical work, due to the shock

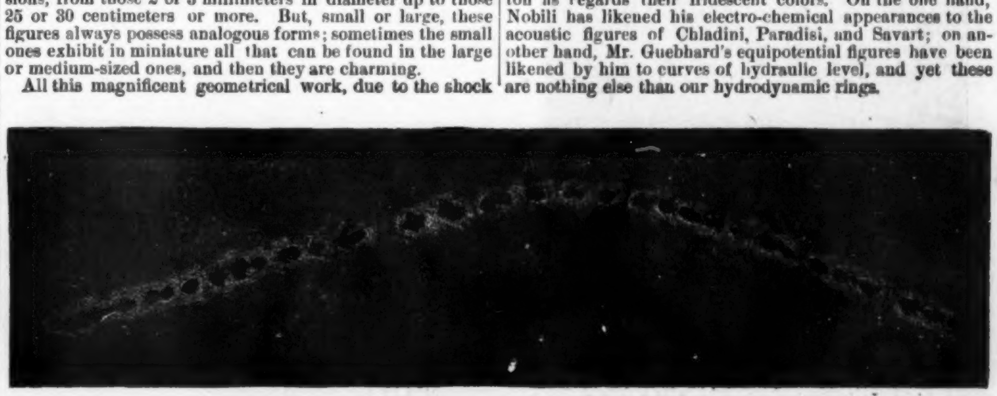


FIG. 28 *c*.

of a column of liquid, this symmetrical distribution of very fine particles of pulverulent material, is done, so to speak, instantaneously, in a very small fraction of a second; and these numerous radiating striæ, these concentric rings, these points of extreme fineness, these graceful, symmetrically arranged ornaments, are reproduced with the greatest fidelity when the same experimental conditions are carried out.

Finally, we may, by employing several tubes instantaneously, produce multipolar rings (Fig. 29), analogous to those that Nobili obtained by means of several platinum wires connected with the same pole, and arranged symmetrically over the plate.

As for the differences between the two classes of phenomena, these relate especially to polarity, to chemical action, and to the structure and iridescence of the rings. The polarity of the metallic plate plays an important but not an absolute rôle in the production of Nobili's rings. I have been enabled to imitate these effects of polarity, however, by sucking and blowing columns of liquid on red lead. In the production of colored rings by electrolytic ray there is a chemical decomposition, it is true, but especially a *mechanical carriage* of the material that constitutes the rings.

The rings obtained by hydrodynamic way usually exhibit in their structure radiating lines of varying delicacy that extend from the center to the circumference (Fig. 30), while in Nobili's rings there is no trace of radii to be perceived. This difference disappears when the hydraulic rings are produced by a fall of a sufficiently long column of liquid from a small height.

The only truly essential difference between hydrodynamic rings and those of Nobili is that the latter exhibit iridescent colors that are not possessed by the former; and yet this difference is not absolute. In fact, let us remark in the first place that in a large number of cases the electro chemical rings are only light and dark alternately, that is to say, monochromatic or sometimes dichromatic. On another hand, the hydrodynamic rings are not totally devoid of color; for, on looking at the flame of a candle (or even diffused daylight opposite a black background) through rings formed of perfectly white sulphate of baryta, we usually perceive around a colorless center an extremely thin zone of a pale blue tint, while the two large external rings, and especially the narrow circles that bound them, are colored orange or yellow, of greater or less depth according to the thickness of the deposit. Analogous and even more pronounced effects of coloration are observed in rings produced by means of white lead; while those obtained with red lead show a central zone of a pale rose color, a succeeding one of an orange yellow, another one of a reddish color, and a border of a dark red.

We see from this that the difference in color between the two classes of phenomena is not absolutely essential. We may conclude then from the preceding effects that rings obtained by hydrodynamic way are in all respects comparable with those of Nobili effected electro-chemically. Finally, the imitation of electrolytic rings by liquid currents extends to other phenomena, such as the following: Priestley's rings, Grove's rings, etc., produced directly upon metals by sparks of static or induced electricity—effects easily imitated by the fall of simple drops instead of columns of water; rings obtained by blowing through a tube upon a layer of moist red lead, or by the shock of a solid body against a resistant plane covered with a like deposit; and the thermic and chemical rings that I made known in different communications to the Academie des Sciences (1876 and 1877), and that were obtained by the action of a flame or of a vapor (vapor of bromine or of hydrosulphate of ammonia) upon a plate of polished metal, and which were like those of Nobili and Newton as regards their iridescent colors. On the one hand, Nobili has likened his electro-chemical appearances to the acoustic figures of Chladini, Paradisi, and Savart; on another hand, Mr. Guebhard's equipotential figures have been likened by him to curves of hydraulic level, and yet these are nothing else than our hydrodynamic rings.

We may add to this those magnetic phantoms of electric currents and magnets, as well as those different physical effects that we have given imitations of (volatilization of a wire by electricity, stratifications of the electric light in rarefied gases, etc.), and we shall thus have a certain number of phenomena of very different classes, which find a common bond of union in our hydrodynamic experiments.

PHYSIOLOGICAL EFFECTS.

Imitation, by a liquid current, of a physiological phenomenon due to discontinuous electric currents.

* I usually employ different heavy insoluble powders, white or variously colored, such as sulphate of baryta, white lead, red lead, and vermilion.

After imitating by liquid or gaseous currents the mechanical, physical, and chemical effects produced by static or dynamic electricity, it remained to find an analogy, from a physiological standpoint, between the two classes of phenomena compared. One experiment in particular, made with another object in view, put me upon the track of this analogy, or, I might almost say, of this similitude.

In fact, when we touch a hydrodiapason traversed by a strong current of water and vibrating rapidly (giving the sound $la = 217{\cdot}5$ vibrations per second), we feel a very intense trembling—a sensation exactly comparable to that which we experience when we touch the rheophores of a voltaic or induction apparatus of weak intensity. This observation might serve as a starting point for researches on the physiological effects that vibratory motions of varying intensity are capable of producing upon the organism.

I shall cite on this occasion the following experiment that I performed a long time ago with another purpose in view. When a tuning fork is held between the teeth by its handle, and is caused to vibrate strongly, we experience a sudden concussion of the brain like a sort of vertigo, a sensation much like that which is felt when we pass an electric current from the teeth to the apex of the head.

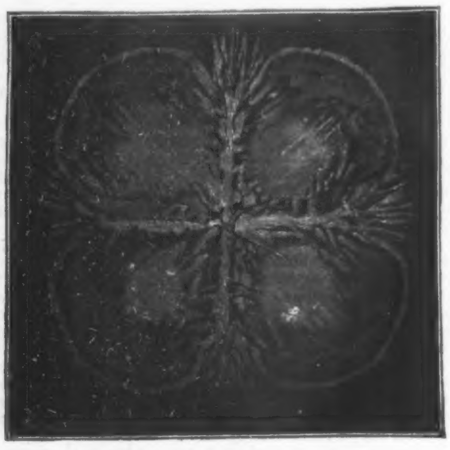


FIG. 29.

On another hand, we know that shower baths, acting by the shock and temperature of the liquid, produce upon the organism physiological effects that are utilized in therapeutics, and that are not without analogy with those of electro-physiology. It is probable that these mechanical and thermic effects would be different and more marked were the liquid current, instead of being continuous, interrupted at more or less approximate intervals. They would, in this respect, imitate those discontinuous electrical currents that produce sensations all the way from that of simple tickling up to the most insupportable pain without disorganizing the tissues, while continuous currents tend to produce the latter grievous effect.

As for the imitation of the physiological effects due to static electricity (that is to say, in general), or to an instantaneous or very rapid electric discharge (either of an ordinary electric machine, of a battery, of a Leyden jar, or of high tension apparatus), this will be found in the sudden shock of a jet of liquid under a more or less energetic pressure.

Generalization of the experiments—Comparison of electric currents with liquid ones—Conclusions:

At the beginning of my researches, I first extended to liquids an effect of attraction produced by a current of air or

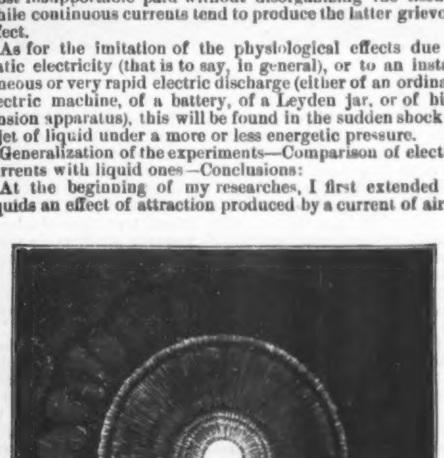


FIG. 30.

steam upon a disk placed at a very short distance from the orifice of the gaseous jet. The phenomena of attraction, vibration, and repulsion that I afterward obtained with liquids in order to imitate the effects of electro-magnetism and induction may be likewise produced with gaseous currents (air or steam) under a more or less strong pressure. We have also seen that the majority of the phenomena of static electricity are imitated almost indifferently by liquid currents or by gaseous ones, and that, finally, an imitation of Nobili's rings may be obtained with a current of air (or of steam) just as it can with the liquids that I employ.

It results, then, from these experiments as a whole that the phenomena of electricity imitable by liquid currents are likewise imitable by gaseous ones. We know, moreover, that the general equations of the motion of liquids are applicable both to liquids and gases.

Comparison of electric with liquid currents.—We have often likened, and with reason, the electric current to a current of water which is flowing from a reservior placed at a fixed height. In support of such assimilation different facts have been offered, the number and value of which have increased with the progress of science. My own experiments add new proof to this manner of seeing.

Let us cite at first a few of the analogies that we find between the two classes of phenomena.

The *constant current* of an electric pile is analogous to the constant current of a liquid (obtained by means of an overflow); and the progressively *decreasing current* of a liquid from a vessel that is emptying without being renewed offers an image of the current of an ordinary pile—the larger the vessel and the narrower the orifice, the longer the flow lasting. "We may," says Mr. Bertrand (*Journal des Savants*, Jan., 1883, p. 20), "compare the pile to a reservoir whose water is flowing out; the speed depends upon the height of the liquid, but the slackening is regulated by its volume."

Several fundamental laws are common to the two classes of phenomena which we are comparing. We shall cite the principal ones:

To the *electromotive power*, E, the cause of electrical motion, corresponds the *pressure* by virtue of which water flows. The *resistance*, R, offered by the electrical conductor is analogous to the *resistance* that the conduit offers to the flow of the water.

The *intensity*, I, of the current circulating in the electrical conductor is represented by the discharge of the conduit.

Now, these quantities, E, R, and I, are connected by the following formula of Ohm, which expresses the fundamental laws of the electric flux:

$$I = \frac{E}{R},$$

which signifies that the intensity of the electric current is proportional to the electromotive force and in inverse ratio to its resistance. In a circulation of water the *discharge is proportional to the pressure, and in inverse ratio to the resistance offered to the flow by the conduit.* So the laws are the same in both cases.

An electric current, then, is comparable with a current of water circulating in a pipe. The velocity with which water flows in a conduit allows us to comprehend what should be understood by the *velocity of electricity*, that is to say, by the time that elapses between the moment at which the electricity is sent in at one extremity of a circuit and that at which it produces at the other a given effect, or, rather, reaches its maximum degree of energy. On another hand, the rapidity with which the pressure of liquids is transmitted is in every respect comparable with that of electricity. We have an example of this in the hydraulic telegraph as compared with the electric.

In a word, the laws of the propagation of electricity in a *variable period* and in a *permanent state* are analogous to those of the flow of liquids. The laws of derived currents are also applicable to the two classes of phenomena.

It results from what precedes that we may, in a large number of cases, regard the electric current as a motion of an incompressible fluid which obeys the laws of mechanics. The stronger the electric current is, that is to say, the greater the quantity of electricity set in motion within a given time, the more the effects produced by such current approximate those of a liquid one.

The small liquid currents that I employ in my experiments on the imitation of the phenomena of static electricity are to the strong currents in the water-mains of a city what the feeble discharges in our machines are to lightning.

When an electric current passes from a metallic conductor of wide section into a fine wire it heats the latter, makes it red-hot or incandescent, and melts it or even volatilizes it, according to circumstances. When a liquid current under a strong pressure passes from a wide tube into a narrow and flexible one (a rubber tube 0·005 m. in diameter and 0·001 m. in thickness, for example), it tends to swell the latter, twist it, and rupture it. The analogy of the two effects seems evident.

To such analogies may be added those that result from my comparative experiments previously described, and which justify the following.

CONCLUSIONS.

After having imitated, by means of liquid or gaseous currents, in numerous experiments, the chief phenomena of static or dynamic electricity, of electro magnetism and induction, of electro chemistry, and of electro physiology, I believe that I am justified in concluding, from the analogy of effects with that of causes, that electric or magnetic phenomena are assimilable to hydrodynamic ones, that is to say, that electricity under the form of a current (of ether or ponderable matter) is analogous to a liquid current, and, in a state of *tension*, is analogous to a certain quantity of liquid distributing itself in a jet.

A certain number of facts due to electricity appear to be the result of a *vibratory motion*. But the difficulty disappears when we remark that an undulatory motion is, in certain cases, capable of engendering a vibratory one, as we have exemplified in our hydrodynamic vibrations. On the contrary, a number of electric phenomena cannot be explained by assimilating the current to a vibratory motion, although the explanation of this becomes easy when we regard the current as a carriage of a fluid—as an undulation.

Mr. Guebhard's equipotential figures on the flow of electricity (*Comptes Rendus*, April and May, 1880, Feb., Mar., Sept., and Nov., 1881) come to the support of the assimilation of electricity to a *flux*, that is to say, to *undulations* and not vibrations. This author has theoretically and experimentally established the fact that his equipotential lines ere exactly represented by the differential equation of the curves of level as given by Lame:

$$\frac{d^2 \varphi}{dx^2} + \frac{d^2 \varphi}{dy^2} = 0.$$

On my side, I have proved by very numerous comparative experiments, supported by photographs of the phenomena imitated, that hydrodynamic rings (curves of hydraulic level) are identical in form with Nobili's. From this double verification results the consequence that these latter can be represented by the general formula:

$$\Delta_2 \varphi = 0,$$

which, consequently, is at once applicable to the equipotential figures of the hydraulic, electric, and thermic fluxes; since, on another hand, I have assimilated the thermic to the electric flux through the correspondence of the relative curves with the velocities of transmission in the two classes of phenomena. (*Mem. de la Soc. Acad. de Maine-et-Loire*, t. xxxiv.).

It results in definitive, from what precedes, that electric and thermic fluxes are assimilable to the liquid and consequently to the gaseous flux.—*C. Decharme*, in *La Lumière Electrique*.

THE NEW CITY HALL, VIENNA.

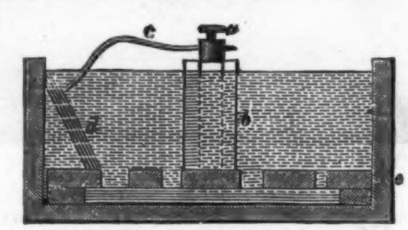
ON the 12th of September, of this year, the new Town Hall of the city of Vienna was dedicated in commemoration of the bicentennial anniversary of the delivery of Vienna from the Turks. The Town Hall is surrounded by the University, the House of Parliament, and the Imperial Theater, and in the neighborhood are situated the Museum of Art, the Museum of Natural History, and the beautiful Votiv Church. The Town Hall was designed by Mr. Friedrich Schmidt, who with rare taste combined the Gothic forms with those of the Renaissance. The length of the building is 505 feet, and the depth 417, and it has seven court yards. In the elevation the building has a basement, a ground floor, which is raised some distance above the street, a mezzanine or intermediate story, and two stories above that. The corners are provided with towers having high Mansard roofs, and in the middle a large square tower is arranged which is flanked on each side by two smaller towers. The ends of the building are also constructed with projecting pavilions, balconies, and Mansard roofs. On the ground floor the building is surrounded by an archway in the customary manner of German town halls, the Gothic arches resting on heavy columns. Very heavy horizontal mouldings of pure Gothic form separate the several stories. The windows are all Gothic, that is, they are constructed with pointed arches and are very highly ornamented, the cornice, which is constructed very heavily of stone, is surmounted by a railing ornamented with statues, and the cornices of the towers bear shields below the dormer windows, which shields carry the coats of arms of the several suburbs of Vienna. Around the towers statues are arranged in Gothic niches, each statue representing one of the countries or provinces comprising the Austrian empire.

The main entrance is in the central tower and leads to a court yard surrounded by arches. At each side of the vestibule two elegant large staircases lead to the upper stories. The main hall, which is the finest room in the building, is oblong, and has the height of two stories with a Gothic arched gallery and a flat arch of ceiling. An additional hall is arranged at each side of the main hall, and on the south side the reception rooms of the mayor or burgomaster are located. In the middle of the south front the other rooms of the burgomaster are located. Adjoining the court yard the hall for the collection of arms is situated, and on the north front the chambers for the magistrate and council are located. The other numerous rooms serve for the officers of the different departments. In the mezzanine the library, the archives, and the rooms for the permanent historical exhibition are located. The new Town Hall of Vienna is no doubt the most elegant structure of its kind in the world today, and is certainly the beginning of a new era in architecture.—*Illustrite Zeitung.*

SCAMONI'S ELECTROTYPE METHOD OF REPRODUCING PHOTO-RELIEFS.

THE question of producing photo-relief plates for photogravure and other mechanical printing methods is one that is occupying considerable attention just now. The most promising way of utilizing the relief of the photographic image is to use the electrotyping process, and this is, in fact, done in the case of the most successful photographic printing blocks. The relief may be built up upon the photographic image by placing this vertically or horizontally in an electrotyping bath, and either the Poggendorff or Smee battery, or the thermo-electric battery of Clamond, as well as the dynamo-electric machine, may be used in the process.

M. George Scamoni, the director of the photographic establishment in connection with the Russian State Paper Office, produces his heliographic plates by electrotyping in the manner following. He employs, and has done so for years past for plates of medium size, an electrotyping trough measuring four feet long and eighteen inches in breadth and height. The trough is made of wood, and is fitted up as shown in the accompanying sketch.



a, the top of the perforated zinc element; *b*, the clay porous cell; *c*, connecting wire, covered with rubber solution to insulate it, except where it is brightened at the ends. One end is made fast to the perforated zinc at *a*, and the other is placed carefully in contact with the relief plate, *d*, the plate being coated with wax and graphite; *e* is the lattice work at the bottom of the battery.

The wooden sides and bottom are lined with lead, and then covered with a hot mixture of old gutta-percha and pitch, the film of the latter being about a quarter of an inch thick, and applied carefully and uniformly. One inch from the bottom of the trough is a lattice, which is kept in its place by leaden weights; under the lattice the impurities of the bath accumulate.

The strength of the sulphate of copper solution should always be maintained from 35° to 38° Baume,* and to insure this strength, some perforated vessels of lead are placed inside the trough full of sulphate of copper crystals.

If it is found that the deposit on the edges of the relief plate is the reddish brown amorphous copper instead of the flesh-colored metal, this is a sign that too much sulphuric acid, impregnated with zinc, has come from the porous cell into the copper solution. In this case there is no help for it but to pour the fluid into a wooden tub and to add powdered chalk so long as any effervescence is perceived. After treatment in this way the liquid is well stirred occasionally during a few hours, and permitted to rest through the night, when it may be filtered and poured back into the electrotyping trough, and brought up to its proper strength by the addition of more sulphate crystals.

The porous cell, which contains well-amalgamated zinc, should shortly before use be filled with sulphuric acid of

* In the case of new apparatus, the sulphate of copper solution is often not of greater strength than 19° to 20° Baume, and then it is usual to add as much sulphuric acid as will raise one or two degrees. Unless sulphuric acid is added in this way, the copper particles precipitated are of a powdery reddish brown character, and will not bind.

SUGGESTIONS IN ARCHITECTURE.—THE NEW CITY HALL, VIENNA.

2¼° to 3° Baume, and according to the size of the plate to be electrotyped, two or four such cells are placed opposite one another. The top of the relief plate should coincide with the top of the zinc.

If, as is required in the treatment of delicate gelatine reliefs, the whole surface of the plate is to be quickly covered with precipitated copper, the porous cells should be replaced during the day with others, duly rinsed in water and freshly filled. Moreover, the ends of the wires must be maintained bright by frequent rubbing with emery cloth.

The plates to be electrotyped, before being put into the trough, should be rinsed uniformly with strong spirit, so that the formation of air-bubbles is avoided, and then as quickly as possible immersed in the solution, and the wires connected up. If a plate has already received a deposit of copper over its surface, then, before a second treatment in the electrotyping trough, it should be rinsed, and lightly brushed with dilute sulphuric acid to facilitate the binding of the new deposit of copper.

Sometimes certain parts of the surface of a plate are a long time getting covered, and an oxidizing action is set up; in this case some little attention is necessary. The plate is raised from the trough in a horizontal position and covered with a sheet of blotting-paper dipped in the sulphate of copper solution, a piece of the blotting-paper being torn off where the defective parts are, and these bare gelatine portions carefully dried with tissue paper. These same defective parts of the plate are then carefully covered with a solution of rubber in benzole. After this varnish has dried—it dries very rapidly—more graphite is applied, by dabbing carefully with a muslin bag containing this powder. The whole operation must be conducted with the greatest care, so that the surface afterward has the appearance of a perfect mirror.

The finest Siberian graphite, which has been rendered a good conductor by treatment in a chloride of gold solution, is the best that can be employed for the purpose. Moreover, it is desirable frequently to shift the plate in the trough and to turn it over, as otherwise there will not be an equal deposition of copper if the battery is a powerful one.

The depositing action may be accelerated by hanging inside the trough a little bag of sal-ammoniac crystals.

The cleaning of the relief plates, when of sufficient thickness, and freeing them from the gelatine film in hot water, is done by Scamoni with the aid of caustic potash, prepared chalk, oil, and charcoal powder; or in the case of very delicate objects by means of benzol and India-rubber.

In conclusion, it may be remarked that generally speaking, notwithstanding the enormous progress that has lately been made in electrotyping, and in the deposition of various metals, the moulding of fine gelatine reliefs still requires much experience, great skill, and extraordinary patience.—*Photo. News.*

A NEW RESIDUAL PRODUCT FROM THE DISTILLATION OF COAL.

By GEORGE E. DAVIS.

THE distillation of coal, or rather, as it is generally termed, its carbonization, is scarcely a century old, and from the very first days of the industry up to the present, nearly the sole aim has been the production of illuminating gas, the tar and the ammoniacal liquor being termed residual products. From time to time there have been proposals to turn the gas into a residual and go in for making tar-water only, and by increasing the yields of these, and by utilizing the gas under the retorts, to manufacture sulphate of ammonia and tar products simply. For some reason or another these projected schemes have never been successful, for the simple reason that tar distilled from coal at a low temperature is not as good as ordinary tar, and with low temperatures the yield of ammonia water is not usually so great as with higher heats. It is true that a considerable revenue may be derived from the sale of coke, but taking all things into consideration there has been so slight a margin, except in special situations, such as distillation on the pit-bank, that but few capitalists have been induced to embark in the undertakings.

The older analyses of coal-gas gave us a very poor insight into its real composition. Bunsen, in his "Gasometry," gave us elaborate methods and calculations respecting the analysis of coal-gas, but recent experiences have shown that many of the deductions are not worth the paper they are printed on. The real and most important illuminating constituents of ordinary coal-gas were entirely overlooked, and so many a practical worker was misled.

Our smoke and fog question, which has cropped up annually, has brought before our notice the gradually advancing use of gas for heating and cooking purposes, and it is evident that the gas for such purposes need not depend for its excellence upon its illuminating power. In fact, its power to deposit carbon during combustion is a defect for both cooking and heating and the use of a gas deprived of its more condensable hydro-carbon vapors would offer many advantages over the old system.

Now reference to the published analyses of coal-gas would, in most cases, lead us to believe that such a task would be impracticable as a manufacturing operation. We are told that the greater portion of the illuminants were olefiant gas, diethyl, etc., or liquids of such low boiling-point as to be reckoned practically with the permanent gases. Investigations extending over a lengthened period have shown me that all the previous analyses of coal-gas are of no value and are moreover inaccurate. The *chief* illuminants are vapors of easily condensable hydrocarbons commencing to boil at below 18° C., and containing many hydrocarbons, even up to solid naphthalene. Now these "illuminants" are easily absorbed by olive oil or rape oil and even by hydrocarbon oils, and it has been found by many experiments that as much as five gallons of these condensed hydrocarbons can be obtained from the gas yielded by one ton of coal.

These hydrocarbons are worth much more than the original coal, plus materials and labor; therefore it seems a very profitable undertaking, when the gas is required for cooking and heating purposes, first to extract the illuminating hydrocarbons. This can be done so completely that the gas on combustion yields only a flame of exceedingly feeble luminosity, this being due to the small quantity of what we may call permanent gases still remaining.

It is clear, then, that in the treatment of coal for heating purposes we have another residual product, if the process is so conducted as to eliminate the illuminating vapors. I propose to call it *crude benzol* in contradistinction to the *crude* naphtha, or first runnings of coal-tar.

Many of you will be aware that a process of carbonization for the sake of these products is now most successfully carried on in the Midlands, and the process has a great future before it; but I have learned by experience that it is only those who can carry on their processes in an exact and scientific manner, and who can obtain the most from their raw material, who are likely to succeed to the end. The differences of temperature, both in retorts and out of them, lead to such variation in the quality of the crude benzol produced as to clearly point to the fact that these operations must be more carefully attended to than in ordinary gas-making.

Ordinary gas-coal of good quality should yield over four gallons of this residual product, and it is very probable that before long a large quantity of it will be sent into the market. Buyers should, however, be cautious. If the heat is too low, more paraffins are formed, and this is only to be discovered by special tests. The ordinary process of distillation and catching all that which distills over at certain mean temperatures is inadequate to discover the presence of paraffins. These are, however, proved by the short yield of aniline oil produced from the benzol in question.

My object in making these few remarks is owing to having heard that carbonizing is a failure, which statement can only have been made by those unacquainted with what is really going on. I am sorry I cannot go more fully into details concerning my own process, but as I intend reading an exhaustive paper at a future date upon the subject, you will soon be able to read it in the admirable journal of our Society.—*Chem. News.*

THE ESTIMATION OF SULPHUR IN COAL GAS.

THE process recommended by Herr Th. Poleck, of Berlin, for the estimation of sulphur in coal gas consists, as usual, in the complete oxidation of the whole of the sulphur compounds to sulphur dioxide, the further oxidation of the dioxide to sulphuric acid by means of brominated caustic soda, and the estimation of the sulphuric acid as barium sulphate. Over a Bunsen burner, which is connected with a gas-meter, is placed a wide tube, open below, in such a manner that the burner penetrates about 2 cubic meters into the tube. The gas-flame should be non-luminous, and not too high. The products of combustion are drawn by means of a water-pump through three U-tubes; of which the first two contain brominated and the third unaltered caustic soda. At the conclusion of the experiment the volume of gas burned is read off at the meter; and the sulphuric acid estimated as barium sulphate. If the sulphureted hydrogen and carbon bisulphide have been separately estimated, the difference between the quantity of sulphur in these compounds and the total amount found gives the sulphur combined with hydrocarbons. The carbon disulphide is to be determined by converting it into the triethyl-phosphine compound. An investigation of the amount of sulphur present in samples of gas from different parts of the apparatus gave: In 100 liters immediately from the retort, 0·600 gramme; before the scrubbers, 0·540 gramme; after them, 0·464 gramme; behind the condenser, 0·440 gramme; and in the purified gas, free from sulphureted hydrogen, 0·276 gramme. The advantages claimed for the process are that it is continuous, does not require very careful attention, and allows of the combustion of large quantities of gas.

EQUIVALENTS OF METALS BY MEANS OF THEIR SULPHATES.

By H. BAUBIGNY.

IF the determination of the equivalents of the metals by means of their sulphates has already been attempted several times, many of these determinations have not presented the agreement to be desired. The cause of these decrepancies lies in the difficulty often found in obtaining sulphates chemically neutral and always constant in composition. By successive crystallizations they can but rarely be completely freed from the last traces of free acid; some of them are even decomposed by water, and for expelling the excess of acid, heat is necessary. But if it is too high, there may be partial decomposition of the sulphates, and the experiment may be vitiated by errors in the opposite direction. The employment of a method of heating by which the sulphates may be submitted indefinitely to a temperature constant and relatively high, but below that of their decomposition, is the first condition for securing to this kind of determination all the precision which it requires.

The use of the sulphur bottle realizes this condition. By numerous experiments, the author has shown that, with the exception of the sulphates of gold and of the platinum group, which he has not studied, this class of salts possesses a stability so great that they may be kept for entire days at a temperature notably higher than the boiling point of sulphuric acid, and that even at this temperature of 440° certain sulphates only lose the last traces of free acid very slowly, and that there is room for employing certain artifices for accelerating the elimination of this acid.

This process constitutes a precise and exact method, since it enables us to avoid any overheating capable of producing incipient decomposition, and removes all doubt as to the state of the salt to be operated upon. The author has thus obtained without difficulty ferric sulphate as a perfectly definite salt of a rosy white.

The preparation of neutral anhydrous sulphates becomes under these conditions as rapid and perhaps even more certain than that of the chlorides, which are also capable of retaining excess of acid or, if their hydrates are heated, of forming basic salts, unless we confine ourselves to the most laborious conditions of preparation.

When the sulphates are thus obtained, their analysis constitutes the second and last stage of the operation. If we take account of the decomposition of these salts by heat by the loss of their acid, as Boussingault demonstrated in 1867, by operating in a furnace heated with the blowpipe, this analysis may reach a high degree of perfection, for it is reduced to a calcination and two weighings, that of the sulphate with the boat in which it has been prepared (the tare of which is known), and that after calcination, which shows the loss of the acid and the weight of the oxide which remains, *i.e.* the proportion of the weights of the acid and the base.

This method of analysis by the dry way, which does not require any manipulation of the matter outside the boat which contains it, thus excluding all causes of error inherent in determinations by the moist way, permits of a greater precision than the processes of the latter kind. This analytical method is also of more easy execution than the determination of equivalents by the synthetic method, *i.e.* the transformation of a known weight of metal or oxide into sulphate—an operation in which there is danger of losses, as Berzelius and Stas declare in their remarks on the extreme difficulty of bringing such a synthesis to a good conclusion.

This process is defective only when the sulphates themselves are volatile with or without decomposition; as those of potassium, sodium, thallium, and mercury, or when the bases themselves are volatile at high temperatures, as baryta and strontia. The determination by the moist way, or that by synthesis, are then the only expedients possible, and in the latter case the last traces of free acid are expelled, before weighing the salt, by heating in the sulphur-stove.

As for the oxides capable of becoming oxidized in the air under the influence of heat, the way of dealing with this property is sufficiently well known.

The solution of the pure sulphate is evaporated in a platinum vessel, protected from the dust of the air, as recommended by M. Stas. Part of the salt is introduced into a tared platinum boat, which is allowed to slide into a glass tube, the open extremity of which alone projects out of the sulphur-stove. It is kept at this temperature until two consecutive weighings, made at an interval of several hours, are constant. For these weighings the sulphate is let cool, protected from the moisture of the air, by cleaning the glass tube at the moment it is withdrawn from the stove.

The time which is required for the elimination of the excess of acid varies according to the kind of sulphate and the quantity operated upon. In general, a constant weight is reached more rapidly if the sulphate is in a pulverulent state. When this last point is reached the boat is put at the bottom of a platinum tube, which is placed in a muffle, so that the open end of the tube projects slightly from the mouth of the muffle. Heat is then gradually applied up to the temperature necessary for the total decomposition of the sulphate.

The use of the platinum tube has a double purpose: 1, to ascertain by examination of this tube if there has been any loss of spirting; 2, to withdraw the oxide, if reducible, from reducing action by permitting the access of the external air around the oxide; the internal atmosphere of a muffle heated with gas and closed having almost always a reducing action.

The author has never met with a trace of spirting in his determinations, and considers that if the temperature is raised gradually it never occurs with sulphates free from excess of acid.

The elimination of the acid is only considered as complete when the weighings, after two successive calcinations, give the same results. This does not exclude a counter-experiment by the moist way, *i. e.*, the resolution of the oxide in hydrochloric acid, and the application of a few drops of barium chloride to the diluted and heated solution.

In order to weigh the oxide the muffle is let cool down to dull redness, and at this moment the boat is rapidly withdrawn from the platinum tube and let slide into a glass case, previously heated in the sulphur-bottle. The case is closed and the boat weighed when cold.

In a further paper the author proposes to show the application of this method to copper, zinc, nickel, iron, aluminum, and chromium.—*Comptes Rendus; Chem. News.*

SEWER GAS AND ITS DANGERS.

By G. W. MCCASKEY, Ph.B., M.D., Professor of Theory and Practice of Medicine in the Fort Wayne College of Medicine, Fort Wayne, Ind.

THE amount of skepticism that exists both inside and out of the profession with reference to the pernicious influences of sewage emanations seems to furnish a sufficient reason for collecting and presenting the most important evidence bearing upon this subject. The evidence is, it must be admitted at the outset, rather contradictory in many instances; but this disagreement is common to questions having to deal with the endlessly varying conditions of living beings, still further complicated by the intricacies of the social organization; and indeed, in order to establish its position among the dangerous environments of life, it is only necessary to prove that it is sometimes pernicious and fatal, however frequently it may appear to be innocuous. There are instances where sewer air is breathed for an indefinite period without any appreciably injurious effects; on the other hand, exposure to its influences even for a short time is occasionally followed by most disastrous results. Contradictory as these observations are, it is believed that they are susceptible of harmonization.

The germ theory of disease, which is constantly approaching more nearly to the status of an accepted dictum, furnishes a ready and rational explanation of the *modus operandi* by which sewer gas conveys the principles of disease; and also explains why it sometimes fails to do so. While it cannot be regarded as demonstrated in any other disease than relapsing fever, and possibly also diphtheria, there is certainly no other theory that accounts for the phenomena of a certain class of diseases in so complete and satisfactory a manner. The evidence in its support, drawn largely from analogy, is so overwhelming as to not only warrant, but challenge, our acceptance, at least provisionally. The researches of Tyndall, Beale, and others have shown that in an atmosphere of ordinary purity there are floating countless germs of living organisms, which only require sufficient nourishment and a favorable environment to develop into organized bodies. For certain organisms these conditions are naturally fulfilled in the atmosphere itself. Usually, however, there is required either an entirely different medium from that ordinarily respired, or a great modification of it before very favorable conditions are presented.

Now it is very well known that the development of micro-organisms in a liquid medium depends, *ceteris paribus*, upon the amount of decomposing or decomposable organic matter which it contains. Pasteur's fluid, for example, contains tartrate of ammonium, 100 parts; cane sugar, 1,500 parts; phosphate of calcium and sulphate of magnesium, of each 2 parts; phosphate of potassium, 20 parts; and water 85·76 parts—the sugar and ammonium furnishing by decomposition the nascent HON and C which are required for the building up of organic structures. These same materials can be supplied in an equally efficient form, but with less precision as regards quantity, by a simple infusion of animal or vegetable tissues. In such media as these microscopic germs find an abundant nutrition, and develop with a prolificness that is astonishing, and almost inconceivable; while in water free from organic contamination, development and propagation are alike impossible.

What is true here is also true of micro-organism in the air, especially because when polluted it is usually owing to contact with putrescent liquids. Germs may be mechanically introduced into either pure air or pure water, but their growth ceases at once. But if, on the other hand, the air contains in adequate amount those elements which go to make up the material basis of life, then they will, under favorable conditions, grow and multiply.

If these biological principles are correctly stated, the next thing to ascertain is whether or not the air contaminated with

the effluvia from sewers, cesspools, etc., does in fact contain the necessary materials for the construction of organized beings. As Dr. Ford, President of the Philadelphia Board of Health, remarks, "The air of sewers varies in composition according to the character of the sewage, the rapidity of flow, temperature, access of atmospheric air, etc." The correctness of this assertion will be at once apparent if we consider the varying products of decomposition which result from the different classes of organic compounds. The precise products of the decomposition of sewage, containing 128·8 grains of solid excreta per gallon, and excluded from atmospheric air, have been very accurately ascertained by Dr. Letbeby. He found that it developed 1·2 cubic inches of gas per gallon per hour for a period of nine weeks. This gas was found to consist of 73·83 per cent. of marsh gas (which is composed of one part by volume of carbon to three of hyrogen), 15·9 per cent. of carbonic acid, 10·19 per cent. nitrogen, and 0·08 per cent. of sulphureted hydrogen. The decomposing sewage mud in the Seine evolves gas which Durand-Claye found to consist of 72·88 per cent. marsh gas, 13·3 per cent. of carbonic acid, 2·54 per cent. of carbonic oxide, and 4·58 per cent. of nitrogen *and other gases*. Of course such an atmosphere as this cannot be found where atmospheric air gains entrance. These analytical results are only given to show what the products may be. It will be seen that all the elements which enter into the formation of the low organism are represented.

Now, what is the practical lesson which these truths teach? It is not unmistakably this: That the germs of any disease, if sown in an atmospheric soil which is comparatively free from organic pollution, will be almost infinitely less liable to develop and propagate their kind than in opposite conditions. Given a case of specific disease, and the chances of conveying the disease to others will depend in large part upon the character of soil in which the disease germs are scattered, and the possibility of communicating their products by gaseous emanations or otherwise to healthy subjects. It seems evident that the whole question of the propagation of disease by sewer gas finds its solution here. Sewer air is more likely to convey disease germs simply because it is a more fertile soil for their multiplication. In some disease the facts seem to warrant us in concluding that the organisms which produce them are extremely tenacious of vitality, and have a wonderfully resistive power. The germs of scarlatina, for instance, are believed to be capable of retaining their virulence for months or possibly years. Others again seem to be very limited in their life term. In the latter case, if they are sown in a barren soil, *i. e.*, pure air or pure water, they must soon "starve out." Sewer gas then cannot produce a specific disease unless the specific germs of such disease are in it, any more than a rich alluvial deposit can produce an oak without an acorn. But who can be certain that these intangible germs are not lurking in some cranny, ready to do their deadly work when opportunity permits? The only safe thing then is to be rid of this hot-bed of infection, which breathes pestilence and death.

After this general view of the subject let us glance at the evidence bearing upon a few individual diseases. First in respect of typhoid fever. Liebermeister, in discussing this question, uses the following language: "When we find that most of the scholars in some schools are attacked with typhoid fever in a succession and intensity corresponding to the degree of their exposure to the gases arising from an open sewer (Murchison on fevers, page 443), we can hardly doubt the way in which the infection is produced. Similar experiments, in which the spread of the infection by the air seems the only possible way, are not uncommon. . . . We may fairly assume that infection can be produced by the exhalations from privies, sewers, etc., in which typhoid poison exists."

That typhoid fever is produced by the emanations from sewers, cesspools, etc., *in which are its germs*, is proved by conclusive evidence.

But there are other diseases which it is believed may result in the same way. Bayles, for instance, in his treatise upon "House Drainage," gives the following list of diseases thus conveyed: Cholera Asiatica, cholera morbus, cholera infantum, dysentery, diarrhœa, small-pox, scarlatina, diphtheria, measles, typhoid fever, yellow fever. This list, Mr. Bayles says, is by no means complete. Neither is any attempt made to place the diseases in order of importance as "sewer gas diseases." With reference to some diseases in the above list there is room for doubt. Dr. Ford says: "There is some evidence that scarlet fever may be communicated in this way." On the other hand, Thomas says that "improvements in house drainage have no effect upon the prevalence of this disease."

Diphtheria, contrariwise, may have an undoubted connection with sewer emanations. Oertel says that "when it first invades the hovels of the poor where the air is impregnated with animal emanations, and other sources of putrefaction fill the air with their effluvia, it only follows the general law," *i. e.*, of zymotic diseases. Prof. Kedzie, President of the State Board of Health of Michigan, says: "This very year (1878) diphtheria and sewer gas have walked hand in hand through Pittsburg, the disease being directly as the exposure to this gas, as is clearly shown by Dr. Snively." De Chaumont says: "It would certainly seem as if the disease was capable of being generated by any sewage whatever placed under peculiar circumstances." It is perhaps scarcely necessary to observe that this belief in the origin of the disease germs *de novo* is not in accordance with the teachings of modern science, which is against the anutochthonous origin of any living forms. Wilson, in his "Hand Book of Hygiene," says that "in country districts outbreaks of diphtheria due to sewer emanations are not uncommon."

The evidence with reference to cholera seems to be pretty conclusive. The outbreak of the disease in the London Work House in 1866, was due, according to Radcliffe, to the sudden escape of sewer air from a drain which contained the excreta of cholera patients. De Chaumont observed two cases at Parkhurst in 1854 in which the cause seemed to be opening an old latrine. Dr. Edward Goodeve says: "The places in which the air is most vitiated from privies, cesspools, drains, and decaying animal and vegetable refuse are those in which cholera has generally been most fatal and most widely spread."

What has been thus far said is in respect of specific diseases, requiring the presence of specific germs; and while sewage gas can not fairly be charged with the genesis of these diseases, yet, owing to the fact that it furnishes a favorable nidus for the propagation of their respective germs, it constitutes a standing menace to health and life—a menace which is too often realized in the decimation of a community.

There remains for consideration the effect of sewage emanations which do not contain germs of disease. It is the evidence bearing upon this question which is so contradictory. On one side the observations of Dr. Guy and Parent du Chautelet are to the effect that those individuals who, by their occupation as scavengers, are constantly exposed to the inhalation of putrescent matter, are quite as healthy as those engaged in other occupations. Dr. Guy's opinion is based upon the comparison of 101 brickmakers with 96 nightmen, scavengers, and dustmen. He found that the number of cases of fever among the former exceeded those among the latter. But even some cases of fever occurring among the brickmakers, which may have been either typhus or typhoid, were caused, Dr. Guy admits, by sewer emanations. "The number of men examined by Parent du Chautelet was very small."—[Ford]. It is well known that vital statistics when tabulated and used for purposes of study must be sufficiently extensive to somewhat reduce the comparative magnitude of aberrations which might entirely vitiate conclusions drawn from a small number of observations. It it therefore scarcely defensible to arrive at such sweeping deductions from such narrow premises. And even the cases given, in the language of Dr. Murchison, "scarcely justify the inference drawn from them."

On the other hand, there are numerous cases which establish incontestably the production of toxical effects from sewer gas, when specific germs were absent; at least when no specific disease was produced. A notable instance in point occurred in New York city in May, 1878. A family of five individuals was prostrated by sewer gas diffusing itself through the entire building. The waste pipes leading from wash basins, bath tubs, etc., were entirely destitute of traps, and the effluvia were thus easily forced out, perhaps, by a sudden increase of atmospheric pressure in the pipes, which might have been due to a rapid augmentation of sewage, thus displacing the gaseous contents, or a strong wind blowing against the discharge opening if this were exposed. Prompt action by the Board of Health alone saved the family from what might apparently have been a fatal result.

In the well known case at Clapham, in 1829, twenty-one boys were attacked with vomiting, purging, and great prostration, as a result of exposure to the effluvia arising from sewage removed from a long blocked drain, and spread upon a garden near the play ground one or two days before the attack. Two of these cases were fatal. The odor was extremely offensive, and the cases may be regarded as typical ones of acute poisoning from sewer gas, apparently without the admixture of specific germs. Cases resembling these except in severity are of rather frequent occurrence. Diarrhœa is rather a common symptom. So also are indigestion, inaptitude for both physical and mental exertion, and general malaise, which rather indicate a general disturbance of health than any definite ailment. Many a case of "general break down" is due to constant inhalation of sewage effluvia resulting from some defective waste pipe—thus gradually and insidiously undermining the constitution until it at length either gives way or is overwhelmed by some specific disease the inroads of which might otherwise have been successfully resisted. Thus it predisposes to numerous diseases.

In the Clapham case above referred to, the men who hauled and deposited the sewage escaped all ill effects. This suggests an interesting question. Is there a tolerance established on the part of the system, as we know to take place elsewhere? The poisonous effects of sewer gas above referred to can scarcely be due to any of the gases of definite chemical composition revealed by analysis. Otherwise, similar symptoms would result from their inspiration in the laboratory, which is not true. We must therefore look beyond these for organic particles or germs with which the microscopist is dimly acquainted and the chemist scarcely at all. These germs may be, and, if they exist, probably are, just as "specific" as those ordinarily so known. That their visible effects are less "specific" argues but little. Is not the immunity referred to plausibly explainable upon the basis of ascertained facts resulting from Pasteur's experiments in protective inoculation, as well as the long known law governing specific diseases in this regard? In such cases as present continuous symptoms of poisoning, the cause may reside in purely chemical non-living combinations of organic matter as distinguished from vital. Of course these views are purely hypothetical, and in the present condition of our knowledge cannot be otherwise. But it seems more than probable that future investigation will verify some such explanation of these phenomena. In the mean time the established fact remains that putrescent air, although apparently devoid of what are at present known as "specific" germs, may yet produce results which are prejudicial or even fatal to life.

Offensive odors are sometimes present, though not essential th virulency; the most fatal consequences frequently following the inhalation of odorless gases. Indeed, as above intimated, the principles which cause the odors are practically destitute of poisonous properties. They are simply the outposts which betray the presence of the enemy.

In closing this brief review of the subject it may be well to call attention to, and emphasize one source of danger. We are very apt to associate our ideas of impure air with low, damp localities, and ascribe to the elevated portions of a city a pure and healthful atmosphere. The fact is, however, that if sewer gas is displaced by a sudden accession of sewage or storm water, it is very apt to be crowded to the more elevated regions, if there is not free ventilation, before being driven from the pipes. Thus its effects may be found where least expected, and ascribed to wrong causes for this reason.

The question of how to deal with this danger to health is foreign to the scope of this paper and may form the subject of another.—*Fort Wayne Jour. Med. Sci.*

ENTOMOLOGY AND MEDICAL SCIENCE.

MEDICAL science finds itself embarrassed in the presence of a dried and withered body, when asked the question what was the cause and what the time of the death of the individual whose corpse it contemplates. Recently, Signor P. Meguin has made investigations with this in view, thinking that a clew to a relative answer to such inquiries might be found in the succession of insects and sarcophagous mites that attack a body not entirely exempted from their approach. Entomology aids this inquiry by its knowledge of the reproduction of insects and of the flesh eating mites, of their metamorphoses, of the different length of time required for their evolution, of the character of their food, etc.

A corpse exposed to the free air is invaded by a number of insects that deposit their ova upon its surface and at the entrance of the natural foramina; the larvæ that arise from these ova penetrate in all directions to feed upon the humors of the body and thus effect decomposition. The flesh eating diptera and some coleoptera do so. Some larvæ of the diptera and coleoptera absorb the fluid juices of the body and reduce it to the condition of a skeleton saturated with the fatty acids; the larvæ of the *Dermestes* then attack all that remains of the fatty matters. There then remain only the dried organic parts, the sinews, skin, and muscular fibers, which in their turn are destroyed by the *Anthreni* and the *Acari* of the genera *Thyroglyphus* and *Glyciphagus*, replacing them with a pulverulent material that covers the bones, and is composed of thin shells, of those of the pupæ, and of their excrements.

In view of these facts Signor Meguin has been able to fix the approximate period of the death of an urchin eight years old, found shut up in a soap box and in the condition of a dried mummy. The numerous husks or shells of the larvæ of *Sarcophaga laterius* and of *Lucilia cadaverina* represented the remains of the insect ravages of the first year, those of the larvæ of *Dermestes lardarius* of *Anthrenus museorum*, and the bodies of the adults of *Thyroglyphus longior* and *T. siro* represented the work of the second year. The child had been dead about two years, and moreover, as there were numerous bodies of *Pediculus capitis*, with which the skin was covered, it indicated that the unfortunate had died completely abandoned, and under circumstances of extreme filth. In a similar case the perspicacity of S. Meguin enabled him to determine exactly the date of a death afterward proved to be correct by the confession of the author of the crime. These appear to be substantial advantages, which entomology may multiply for the benefit of medical jurisprudence.—*Rivista Scientifico-Industriale.*

DEMERARA GREENHEART.

GREENHEART as a wood is well known, but it has been unnoticed save by ship-builders and marine engineers, by whom, from possessing special merits, it is highly esteemed. Its merits primarily are its durability and its power of resisting the ravages of worms and other forms of marine life. Outside the influence of the ship-builder and the marine engineer it is little known, and as a wood has been treated with undeserved neglect. We are of opinion that it possesses merits outside the influence of these trades, and that such merits have only to be pointed out to bring the wood into prominent use.

Greenheart is the natural associate of teak-wood, as it is used side by side with that wood, both in shipbuilding and in marine engineering. It is one of the ten woods classed A1 at Lloyd's. Greenheart, although a product of the forests of South America, only rates at about half the price of teak-wood, the one being purchasable at about 3s. 6d. per cubic foot, and the other at about 7s. Why this difference should exist it is not easy to explain. In shipbuilding it may be that the weight of greenheart is against it, for if specific gravity is 1·149 against teak 0·800, and oak 0·928. Teak, although a most expensive wood, and one not possessed of pleasing grain or color, has made considerable progress outside the above trades. It is well known in the building of railway-carriages, for staircases and floors where a great amount of wear has to be contended with; but its compeer, greenheart, is unknown in these special departments of trade. In railway-carriages it may be that greenheart is discarded on account of its weight, which, it will be seen, is about one-third more than teak-wood and one-fourth more than oak; but for stairs, floors, and a hundred purposes in the constructive arts, we fail to see why it is not adopted in preference to any other wood. It has the qualities of being hard, tough, strong, and elastic, added to which it is very durable in point of wear, and practically indestructible with regard to fire. As a building timber its price, compared with its strength and durability, ought to place it in the foremost rank. It is imported in logs, from 24' to 50' long, and in squares ranging from 12" to 24", and logs are recorded as long as 70', and 24" square, so that no objection can be taken to it on the score of size. In color it is not unlike oak, except that it has a greenish tinge. Its face is lustrous, but except in figured logs it cannot be termed an ornamental wood. The figure, which is somewhat rare, partakes of that found in American birch, caused by the fibers in the outer wood, under certain conditions of growth, taking a waved or tortuous course. It has the specialty of being remarkably free from knots, and of being more free from ring and heart shakes than any other wood. The sap-wood is most difficult to tell, and although there are experts who assert that it forms one-fifth to one-third of its bulk, there are others who assert that it is a wood free from sap, or, if not free, that the alburnum, like that of the lignum-vitæ, is as durable as the duramen.

As a weight-carrying wood, we question, when its size and practicability are taken into account, if it has a rival. The breaking weight of a specimen 7' long and 2" x 2" square is 1,332 pounds against teak 877 pounds, and oak 900 pounds. Its crushing weight on a cube of 4" x 4" is 98·037 tons, against teak 87·05 tons, and oak (green) 38·041 tons.

A peculiarity in greenheart is that it is liable to shake or split at the ends; this is such a marked movement in planks cut from the logs that they are invariably bound with hoop-iron. Charles Waterton, the great naturalist who traveled in South America from 1812 to 1824, speaks most highly of the greenheart; and the Rev. J. G. Wood, who reissued Waterton's work in 1879, says that Waterton brought some greenheart wood to this country, to be made into furniture for Walton Hall, Yorkshire, and very excellent furniture it is said to have made. Mr. Wood thinks it possible that this furniture may still be at Walton Hall.

As a furniture wood, its color, during the present fashion for dull goods and sage greens, cannot fail to be acceptable. Its great strength admits of its being used in small volume, its small dimensions compensating for its great weight. From its compact nature it is susceptible of elaborate ornamentation, more especially in the lathe. In hardness it compares somewhat with ebony and satinwood, and hence, when used in the veneer, would admit of being cut to a fine gauge. As to its ornamental character we know very little; but there are figured specimens, the use of which is now under the consideration of practical cabinet-makers.

The Rev. J. G. Wood informs us that there are three varieties of greenheart—the yellow, the black, and the "mainop"; it need scarcely be said that the yellow is the variety generally known in this country, and the one to which the above remarks refer.

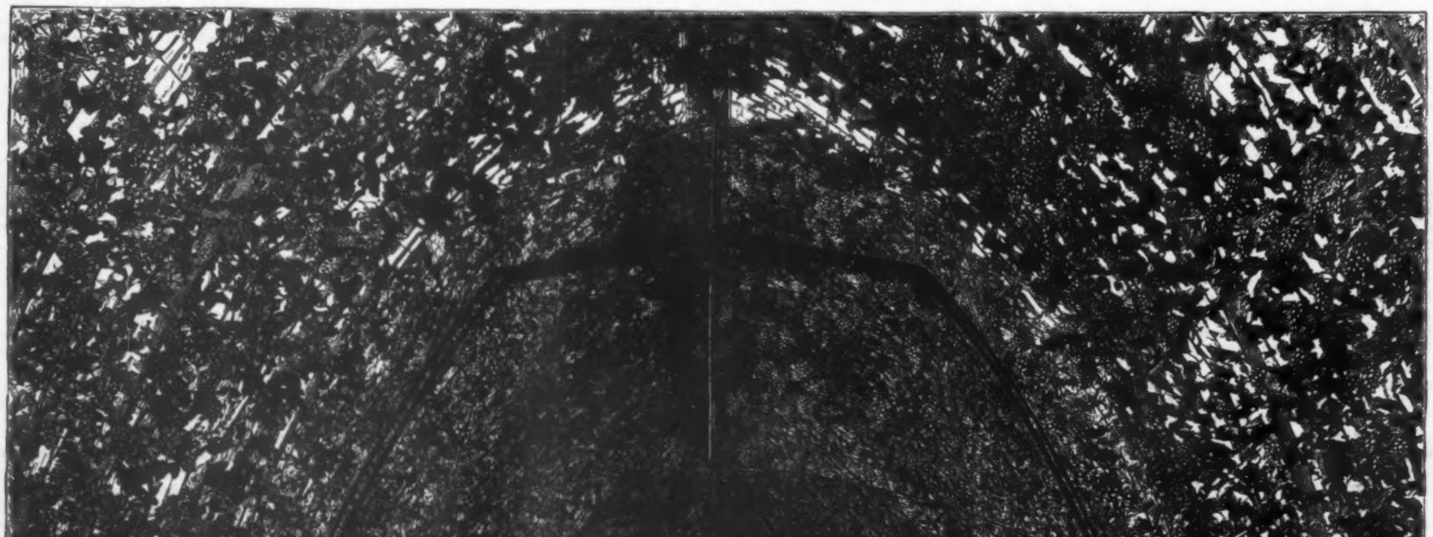
We have of late heard a great deal on the subject of fire-proof or fire-resisting materials. Cased wood and concretes have received prominent notice, and the opinion is general that wrought and cast iron are questionable materials. Wood, we know, is an inflammable material, and on the average forms the bulk of the fuel that keeps up the flames in burning buildings; but there are woods of a highly inflammable character, and others which are slow or difficult to burn. The ordinary fir-wood, which forms the bulk of the timber in every building, is highly susceptible of fire, and when once ignited is difficult to extinguish; on the other hand, it is well known that oak as a timbering wood will not ignite

or feed a fire, in like degree to fir wood. The secret of this lies in the fact that oak is a hard, compact wood, while fir is soft and resinous. It thus follows that all hard, dense, or compact woods are in large degree uninflammable. Compared with greenheart, oak is a soft, porous wood, one that fire would make inroad upon, while greenheart would stand uninjured. As a wood, we do not maintain that greenheart is fire-proof; but if wood is to assume fire-proof qualities in any degree, such qualities are only to be found in hard, dense, and compact woods, at the head of which we may safely place greenheart.

For bearing purposes greenheart has no rival, and we maintain that beams of this wood possess high qualities in the direction of resistance to the inroad of fire; such beams, if cased with plaster or other fire-resisting material, would stand uninjured in any ordinary fire, and would be more reliable in their conduct than cast or wrought iron.

This question of introducing hard wood into buildings as a fire-proof material is a new one, and one that calls for our most serious consideration. There is no doubt that it is more qualified to resist the inroad of fire than ordinary fir timber, or than that highly combustible wood that is now so generally used, "pitch-pine." This being the case, what is to prevent us from using such non-inflammable woods as greenheart for the internal woodwork of our buildings? Taken as a timber for bearing purposes, we have to face the fact that it is double the cost of fir-wood or pitch-pine. Against this drawback we have the fact that one-third of the scantling size may be reduced throughout in the case of greenheart, to balance the bearing qualities of the three woods. The breaking weight of a 7' scantling 2" x 2", placed 4' between the bearings, is as follows:

Fir-wood.	Pitch-pine.	Greenheart.
864 pounds.	970 pounds.	1,332 pounds.



THE GREAT VINERY AT CHISWICK.

This reduction of one-third in volume goes far to assimilate the cost of greenheart with fir-wood and pitch-pine, after which the difference is far outweighed by the advantage of introducing a less volume of wood into any given building where it may in case of accident become food for fire, and in that less volume being of a hard or uninflammable character.

We are free to admit that the fire-resisting qualities of greenheart have not been tested in burning buildings, but we have the fact that fir-wood is soft and inflammable, and that hard wood is in every way its opposite. This is well known so far as kindling is concerned, for if it be hard wood, such as mahogany, a fire cannot be kindled with it, nor will it be readily kept alive by feeding with such wood. A block of such wood will invariably damp out a fire, where one of fir wood or pitch-pine will prove a living coal. A friend of the writer, an old practical ship's carpenter, who has circumnavigated the globe, says of greenheart: "It is as hard and strong as iron, and so dense and compact that fire will scarcely touch it." This being the case, why not, we ask, bring it prominently forward as a building timber, and use it in place of the highly inflammable and cumbrous woods which are so undeservedly popular?

The test of inflammable and non-inflammable woods rests largely with their specific gravities, a light soft wood being more susceptible of fire than a heavy hard wood, especially so if the soft wood is charged with oil and resin. to assist those interested in this subject, we give the specific gravities of the following woods, 1,000 being the equivalent of water—that is, those under 1,000 will float with more or less buoyancy, while those over 1,000 will sink below the surface:

Quebec yellow-pine.	Baltic fir.	Pitch-pine.	English oak.	Greenheart.
513	563	635	828	1,149

The above statistics are obtained from the Government dock-yards. We extract them from the valuable work by Laslett, "Timber and Timber Trees." It may be said that the specific gravities vary greatly with different examples of soft woods, but that they are very uniform in the hard woods.

The high specific gravity of greenheart is shown in the respective weights per cubic foot: Quebec yellow-pine, 32·08 pounds; Baltic fir, 35·09 pounds; pitch-pine, 39·37 pounds; English oak, 51·72 pounds; greenheart, 71·82 pounds.

On all hands we see that greenheart is a wood of great strength, durability, and size, one highly endowed with fire-resisting qualities; one that necessitates a less volume of wood being introduced into a building for a given amount of work; one, considering the lightness of the scantlings required, that is low in price; and, lastly, one practically within reach of the builder, when the policy of using soft, inflammable, and bulky woods is set aside.—*Timber Trades Journal.*

CHISWICK.

Although there is no pretence whatever to display in so lofty and unsuitable a house evidences of high-class grape culture, yet those who look upon the ripened bunches of luscious fruit which hang overhead, happily so high out of reach, will admit that the crop, if not a grand one, is a good one, and such as few gardeners would not be delighted to possess. The house contains some twenty kinds of grapes, the major portion of which are black. The vines having been planted in 1857 are now verging upon thirty years of age, and as the herculean task of lifting the roots, remaking the borders, and replanting has not so far been possible, they have been fed from above as best they could, and the result is seen in the pleasing and profitable crop hanging so luxuriantly from the lofty curvilinear roof.—*The Gardeners' Chronicle.*

OBSCURED GLASS FOR VINERIES.

Some four years ago I undertook the renovation of some old vines for a gentleman near here who had just come into possession, he undertaking to roof the vines in fresh with rolled rough plate glass and provide everything if I would direct operations. The vines were submitted to the usual renovatory measures, and responded well to our efforts in the production of good fruit and healthy growth, the two most striking things about both being the good quality of the fruit and especially of its color, and the health of the foliage which is less affected by red spider than it was under the clear glass, and less so, in fact, than any vines I know of, although the house is heated by a flue. The green state of the foliage till and after the fruit is ripe I attributed solely to the subdued rays of the sun upon the leaves through the rough plate glass, which also obviates the necessity of giving so much air, thus trying the foliage less than it otherwise would be. The good fruit so well matured was put down to the permanently healthy condition of the leaves. The light on sunny days is always bright enough, but the rays are diffused. I record the fact at all events, for it shows, at least, that the prejudice against rough glass is a false one. It is well known that this kind of glass is used for camellia houses in order to protect the foliage from the strong light, and no doubt it exerts a similar influence on vines. Under clear glass on bright days, supplemented by hot water pipes, the sun is often very trying.—*S. W., in The Garden.*

IRRIGATION IN CALIFORNIA.

SIX COMPANIES FURNISHING WATER FROM KING'S RIVER TO RECLAIM PARCHED LANDS IN THE SAN JOAQUIN VALLEY. ESTIMATED CAPACITY TO WATER 650 SQUARE MILES.

From Letter of John L. Dow, M.P. to *Town and Country*, Sydney, Australia.

Fresno is 207 miles southeast from San Francisco, Cal., and is situated on that portion of the Central Pacific Railroad which joins on to the Southern Pacific line, which in turn connects with the Atchison, Topeka, and Santa Fe road, and so on to the other Eastern railroads, forming what is known as the southern route from the Pacific Ocean at San Francisco to the Atlantic at New York.

The date of my visit to Fresno was the 19th August, and the subject to be treated is irrigation. The first thing necessary will be to disabuse the minds of any who may have the phrase "irrigation works" associated in their thoughts with "grand canals" or other large, elaborate, and expensive operations. Simple in the extreme are all the works and all the operations round here. More appropriately could grand, eloquent adjectives be used to describe the results which are being obtained from these simple, crudely constructed "ditches." "Yes, yes, that may be all very well," probably the average reader of these letters may interject, "but Fresno is very likely surrounded by such a wealth of naturally formed can als in the shape of overflowing rivers and brimming creeks that the conditions in that locality cannot be fairly quoted." It is just here, however, where a visitor is most impressed. Coming in from New Mexico toward San Francisco, one finds himself traveling through country that reminds him of the Old Man Plain of New South Wales, the Wimmera prairies of Victoria, the Port Augusta back blocks of South Australia, or the Barkley table land in Queensland. For the last 1,000 miles of the traveler's journey previous to reaching Fresno his train has pursued its monotonous course through 100 miles after 100 miles of open, treeless plain, swith here and there a few mobs of cattle and at wide intervals the rude dwelling of the half savage cowboy. The prospect is agreeably diversified within 482 miles of San Francisco by our arrival at Los Angeles, and for some miles the route is through the luxuriant orchards of that lovely district. but again you pass into the country of thinly populated cattle ranches until Fresno is reached.

Here we get out at a busy township of some 20,000 inhabitants, where all is life and evident prosperity. August is the first month of autumn in California, and during the day the glass has recorded 95 deg. while hung in the shade of the cars. At dozens of stations has the train stopped during the 24 hours preceding our arrival at Fresno, but they are merely stopping places, with a few shanties scattered around the railway water tank; and loitering around are some "greasers," as the slovenly Mexican stockmen are styled. Away on either side of the single track, unfenced railway line stretch the open plains of the same rich, red loamy soil

as is seen at Fresno, but the broiling sun beats down upon the thin, burnt up grass, and no prospect could possibly be more uninviting.

At Fresno we have reached about midway of its length along the San Joaquin Valley. The term valley, however, tends to suggest to the reader's mind something different to what is actually seen. This is certainly a valley, and it is traversed along its center from south to north by the San Joaquin, a river resembling, during the larger portion of its course, the Yarra between Melbourne and Williamstown, Australia. But from Fresno you see no sign of a river. It will be remembered that this valley is of great extent. From the head of the San Joaquin, in the south, to the head of the Sacramento, in the north, is 502 miles, and the average width between the coast range on the west and the Sierras on the east, which inclose this valley, is 110 miles. When one alights from the cars, therefore, at Fresno, there is very little appearance of a valley. Through the dim haze created by the heat one can discern the towering outline of the Sierras away to the eastward, but the lower range coastward is not visible. All is level. Getting into the middle of the township you find, however, that there must be production going on somewhere handy. Prosperous looking farmers are driving smart pairs in their Studebaker wagons, or spanking trotters in the light, single-seated buckboard. Well stocked stores are driving a brisk trade. Agricultural implements are displayed in great number, and of the latest make, while from a fruit cannery down near the station the hum of many busy workers can be heard as you drive past. The Grand Central Hotel, to which we are driven, is of superior sort, giving further indication of Fresno's prosperity, and from the clerk we obtain the names of two gentlemen engaged in the irrigated land business. We ascertain that the main ditches by which the Fresno district is watered come chiefly from the King River, a tributary of the San Joaquin, the source of which is in the Sierras, and the most abundant water supply season is from the latter part of spring to the beginning of summer (from March to May). The ditches run from 15 to 50 miles, with the farmers' subsidiary channels tapping them all the way from the start.

As we drive out of Fresno we look back upon the town standing in the midst of what would be as open and arid a plain as any of the rest of the dreary country passed over between Los Angeles and our present position, but for the fact that scattered over the scene, and at intervals of from three to five miles apart from each other, are to be seen what appear in the distances to be groves of trees, studding the plain at all points around Fresno. We make for one of these "clumps of trees," and are a little surprised at its distance. On this level kind of country, and probably owing in part to rarity of the atmosphere, what looks like one mile proves five. The "clump" of trees also begins to spread out as you near it, and develops into a "colony." These colonies are a marked feature of the Fresno irrigation settlement. A dozen different colonies, covering areas of from 6 to 15 square miles each, are all so rapidly expanding as to suggest that in time the intervening plains between the colonies will all be filled up. Under the colony system, water is first supplied by a company, which constructs the main ditch; then the land, increased in value by the permanence of occupation assured by the water, finds buyers, who are enabled to settle compactly. The land is divided into 10, 20, and 40 acre lots, and is found capable of furnishing a good living to each family, while many admit that they are making money. These small farms make continuous villages for many miles, with all the advantages of society, schools, and churches.

What a change you experience when you pass from the hot plain into the shady avenues! The outer boundary of a colony is distinctly marked. Outside, a glaring summer sun beating down upon an arid waste; the soil is in itself rich enough, but it has no water; inside, grateful shade, water running along the ditches on each side of the main road, luxurious vegetation, neat, well kept houses, prosperous looking people, here a vineyard, there an orchard; on one hand the owner of a forty acre block has his farm subdivided into four 10 acre lots, carrying each vines, fruit trees, wheat, and green crops respectively, while on the other may be observed quite a large landed proprietor, who has accumulated 160 acres. Every homestead has its windmill engaged in pumping water into an elevated wooden reservoir resembling a wine vat, and from this a supply sufficient for house and stock requirements is got by gravitation. This water is obtained from wells, and here comes in a significant fact in connection with irrigation. Ten years ago water in the district was not to be got by sinking; now it can be obtained anywhere within the areas reached by the irrigation ditches at from 10 to 40 feet. The continued soaking of the land by the repeated flooding of the water has supplied the wells. The oldest colony in the Fresno district only reaches the age of ten years, but ten out of a total of fourteen are under five years since the first settlement was made. The absence of fences is a feature. Each colony is allowed under an act of the State Legislature to dispense with fences if the majority of the settlement so will it. There are many who fence and do so well, showing that they are able to afford it, but in other places you observe the orchards, vineyards, or grain fields of different farmers abutting upon each other without anything between. The roads are also in many parts only indicated by the ditch on each side, and those who possess sheep and cattle are, under the optional fencing law, obliged to take the responsibility of looking after them in those districts where the majority have agreed to herd the stock and leave the land unfenced.

The farm of Miss Austin, which is situated in Central Colony, is fairly illustrative of the district. Miss Austin is the managing partner in a firm of four, and the total land held is 100 acres. This is devoted to a combination of vine, fruit, and grain growing, with some live stock, for which grass and green crops are provided. The grapes grown are chiefly Muscatels and Sultanas, raisin drying being a specialty of the place. The luxuriance of the shade trees, among which the Australian blue gum, the cypress, and the poplar can be seen interspersed with oleanders, throws a grateful protection from the heat of the sun as we pass between the avenues which run through the farm in various directions, following the course of the irrigation ditches. Forty acres of the farm are under the raisin vines, which are now in their fifth year of bearing. The vines are planted 8 feet each way, thus giving 680 vines to the acre, and these yield at the rate of from 15 to 50 lb. per vine of the Muscatels, while from the Sultanas the yield reaches as high as 100 lb. per vine, 80 lb being considered a fair average. Sun-drying on open trays is the process that has been followed by Miss Austin, as she has always been able to get a superior article in that way as compared with any of the machines. An average of 3½ lb. of grapes has been required to make 1 lb. of raisins, and 2½ dol., or 10s., has been the average price received per case, containing 20 lb.

Concerning irrigation Miss Austin informed me that indiscriminately letting the water cover the grain or maize fields did not matter, but in irrigating for fruit trees and vines the water had to be prevented from going close up to the stems. Little hoed-up ridges were shown me banked up at about 4 feet back from the stems of the fruit trees all round to keep the water back. The theory is, by letting the water sink down about 4 feet away from the tree that the roots follow the water and thus strike deeper and do better.

Within as late a period as ten years ago land around Fresno could hardly be given away. Like Australia, Southern California has its big estates and wheat growing selectors. The large holdings are represented by the Spanish grants, which the United States Government respected at the time of annexation, and these are used as large cattle and sheep ranches. Australian large estates are found in many instances to have appropriated the choicest situations with respect to water frontages, and in the big ranch grants here the same peculiarity exists. Like the Australian farmer of the interior, his Californian *confrere* was, before the irrigation advent, also engaged in waging an unequal conflict under similarly adverse troubles. During an extra severe drought which came in 1871, a few farmers who were more favorably located with respect to water frontages than the majority conceived the idea of digging a ditch from the river and letting the water flood their crops. An official record of the time reads: "At the cessation of the rains in February, 1871 (corresponding with the Australian August), says our authority, the grain was in excellent condition, but March and April came without a drop of rain, when the drought accompanied by severe north winds, turned it yellow and sickly, threatening utter destruction. Some of the farmers then determined to try flooding from the King as a desperate resort, and a few ditches were hurriedly cut. The water was applied in a crude manner, but a single flooding restored the vitality of the crops, and made the wheat yield from 30 to 55 bushels per acre. Much of this land previously failed to find purchasers at 2½ dol. per acre, and its price immediately rose to 25 and 30 dol. per acre." When it is remembered that March and April, the months referred to in the foregoing, correspond with the Australian September and October, and that these are just the months when rain is most needed and least to be depended upon, the peculiar coincidence indicated here is somewhat remarkable. This was the small beginning from which have arisen such grand results in that portion of California of which Fresno is the center.

One of the earliest difficulties that met Californian irrigation came from the large estate owners. In those frequent instances in which their properties lay between the farmers' lands and the river, the right of thoroughfare with ditches was disputed; but one of the earliest acts of the Californian State Legislature, bearing upon the irrigation question, gave free course to the water. I told a friend here, who has had a great deal to do with these early difficulties, about a case in Victoria, where the owner of the Longerernong Estate sued the Stawell Shire Council and obtained heavy damages for putting a ditch through that property for the purpose of getting water from the Wimmera to the selectors at the back; and he informed me that at their worst in California, the big estate men were never able to get a judgment of that kind. Later legislation arranged a system of granting water franchises to companies, which, upon being incorporated and submitting sufficient assurance as to getting on with the construction of main ditching to command a certain area of land, were authorized to draw a proportionate quantity of water at a given point from the river. Thereupon companies were formed for ditch construction, and up to date there are in operation throughout the San Joaquin valley, the Fresno Irrigation Company, with a franchise for carrying 1000 cubic feet of water, estimated as sufficient to irrigate 230 square miles; the King's River Company, with a franchise for 250 cubic feet, to water 62 square miles; the Centerville and Kingsburg Irrigating Ditch Company, with 200 cubic feet of water, considered enough for 50 square miles; the Emigrant Ditch, carrying 50 cubic feet of water; and the Liberty Ditch, 30 ft. The Fowler Switch was just being completed while I was at Fresno, and is to carry 1500 cubic feet, estimated to water about 300 square miles. All these ditches draw from the King's River, which, as has already been noted, takes its rise in the Sierras, and forms the main head of the great San Joaquin River.

The quantities of water referred to in the foregoing estimates of these main ditches are calculated on the basis of a water flow of such a number of cubic feet per second. A water right, which the farmers have to buy from the ditch companies, costs 10 dol. (£2) an acre. Originally the water rights cost 5 dol. an acre, but during the past four years, as the knowledge of what can be done with water has become known, the price has gone steadily up till it has reached the present figure. A water right does not limit the consumer in any degree as to supply. The right gives the claim to take as much water as the area of ground requires, and to draw at any time and as often as the owner chooses. In addition to the 10 dol. per acre charge for water, the farmer has to make his own "lateral," which is the name given to the secondary ditch that taps the main channel, and the work of making laterals, which are ditches 4 ft. wide by 1 ft. deep, is usually done jointly by the farmers who have taken up land in the same direction. The work is performed very cheaply by plow and scoop. Then there is an extra charge of 60 cents (2s. 6d.) per acre per annum payable to the ditch company to cover management and maintenance expenses. For all this the water companies agree to supply water *ad lib.* to each acre of land covered by a 10 dol. water right, maintain the flow of water in the main channel according to the requirements of the number of consumers who have connected themselves on by means of their laterals, and pay the water overseers, whose business it is to charge, look after defined sections of the main ditch, regulate the flow from the main sluice where the water enters from the river, and perform the same office at such sluices where the water enters the farmers' laterals.

A matter apt in a degree to confuse a stranger upon his first inspection of practical irrigation is the way in which the people talk about their flow of so much water per second through the sluices from the main ditches into the laterals. At Salt Lake, under the Mormon irrigation system, the standard quantity of water is allowed to each water right holder at his laterial sluice as one cubic foot per second for each 100 acres. This tends to produce the wrong impression of a certain limited quantity of water being allowed to each consumer. The allowance of water is unlimited, and the arrangement of a cubic foot per second for each 100 acres is simply an arrangement to guide the water overseer as to the flow that he will lay on when a farmer gives notice that he intends to irrigate. Just as at Salt Lake, Utah, so at Fresno, Southern California, the water overseer knows how many water rights are along each lateral, and every morning he looks at his notice boxes, which are attached to the sluice heads at the place where the laterals leave the main channel. The farmers generally arrange to irrigate in such a way as to accommodate each other, but in any case the waterman knows by the notices, stating intention of irrigation on such a day, how many acres are possessed by the persons so advising. His water gauge, which is simply a wooden slot in the lateral sluice head, graduated so as to let a certain number of cubic feet run through in a given time, is then lifted to the necessary mark and the water laid on until the irrigation is completed. Thus, taking the Utah gauge, which is arranged so as to let a cubic foot per second flow through for each 100 acres of land, if A's notice represent five water rights, B's 15, and C's 30, the water overseer knows that 50 water rights want water, and he sets the gauge to run at the rate of half a cubic foot per second. It will be seen, therefore, that this is not for the purpose of measuring the water out by the gallon, but only as a gauge to arrange the flow to suit the irrigation requirements of the several farmers situated along the lateral.

By this gauge, however, you ascertain that water goes further on a given quantity of land at Fresno than at Salt Lake. The water observer's gauge, which is arranged at the latter place to let in a flow of water at the rate of 1 cubic foot per second for each 100 acres, is set at the former upon the basis of 1 cubic foot per second per 160 acres. The cultivator receiving water in the Fresno district at the rate of a cubic foot per second per 160 acres finds that a given area of land is saturated in a shorter time than it takes to sufficiently irrigate a similar area at Salt Lake with the water flowing much faster, viz. at the rate of a cubic foot per second for each 100 acres. From the great similarity of soil and climate of the Fresno district to the prairies settled upon by the farmers in the interior of Victoria, New South Wales, South Australia, and Queensland, I should say that water would with us go quite as far as in Southern California, probably further. Then, a special feature brought out by the actual experience of the irrigation colonies of the Fresno district is the manner in which the water seems to have the inherent power of multiplying its capacity. When the few farmers ten years ago let the water on their perishing crops in the spring the success of the experiment was acknowledged, but it was asserted that the King River could not furnish water enough to make irrigation a matter of any extent or importance. Beginning with the farms nearest the river, however, it has been found that after they had received a couple of good soakings they would hardly take any more. The water that formerly flowed down the river to the sea was intercepted and stored in the subsoil of the land. Where it was supposed that the nearest farms to the river would always require a similar quantity of water upon each successive irrigating time, it has been found that the soil being saturated would not take it in, and the ditches have been extended year by year further back from the river, thus carrying water sufficient for all. Cultivators who at first thought they would never be able to get enough water now find that the most profitable returns—whether as regards the growing of fruit trees, vines, grain, or grasses—are obtained by letting the water in carefully, and not in too great a quantity.

The Fresno Irrigation Ditch Company is the pioneer association of California. It began by taking over, in 1872, and extending the first rude channel made by the few farmers, to which allusion has already been made. It was then asserted that their franchise would of itself exhaust all the available water, but at the date of my visit the ditch companies had increased to the number above noted, all drawing water at different points from the same King River and all able to provide a sufficient supply to their daily increasing number of right buying constituents. The large ranch proprietors, who at first opposed the ditches, are now eagerly availing themselves of the good fortune being thrust upon them by the high values which irrigation has conferred upon their land. There are three classes, engaged in the Fresno land settlement—the water companies, who construct and work the ditches; the land companies, who buy from the large holders, and subdivide into small blocks; and the actual settlers. The price of land at Fresno at the time of my visit was quoted at 40 dol. to 80 dol. (8 £ to 16 £) per acre including the 10 dol. water right. Some 20 acre blocks were shown me that had reached 100 dol. (£20) per acre, because of good position in relation to the water. There was little variation in the quality of the soil, but values were controlled by the lay of the land with respect to easy irrigation. The invariable level everywhere rendered irrigation on the whole easy, but in some places inequalities in the soil necessitated extra expenditure in the way of leveling. From among the cultivators, land agents, and ditch companies alike I had several admissions as to their doing very well, and from none could I hear any complaints with respect to prospects. The land people treat intending settlers with great liberality as to terms, and the water makes the returns a certainty within dates that can be definitely calculated upon.

THE ICE OF GREENLAND AND THE ANTARCTIC.

DR. JAMES CROLL has a paper in the *Philosophical Magazine* for November, opposing the view that the universal ice-covering of Greenland is a consequence of the elevation of the land. He states that no interior mountain ranges have been reported, and holds, as urged by Dr. Robert Brown, "one of the highest authorities in matters relating to Greenland," that the region of the great interior ice-field is like a broad-lipped shallow vessel, filled with the glacier as with a viscous material, and pouring portions out through breaks in the margin. He also accepts as most probable the opinion, long since expressed by Giesecke, and more recently by Dr. Brown, that the country is really a collection of islands fused together by ice.

Dr. Croll also argues that the Greenland condition is probably that of the Antarctic—a collection of rather low islands "bound together by a continuous sheet of ice," as Sir Wyville Thomson has said, covering a space of about 4,500,000 square miles. This conclusion as to its little elevation is stated to follow from the low and even top, and the structure, of the Antarctic ice barrier. Its horizontal stratification bands indicate, by their number and the thickness of the mass, a long period of annual deposition of snows; and also that the barrier is probably removed hundreds of miles from the region of dispersion, especially since there are none of the usual marks of a former glacier condition, such as come from movement along valleys or fiords. The layers constituting the ice-mass become gradually thinner downward; and this, while partly a consequence of compression and melting, is due more, Dr. Croll says, to the increasing breadth of the earth southward from the pole, this alone requiring that a square foot of ice coming from latitude 89° should occupy thirty square feet on reaching latitude 60°, and hence be only $\frac{1}{30}$ of a foot thick. Hence

relative thickness is an indication of distance traveled, and "a layer near the bottom may have been traveling from the pole for the past 10,000 or 15,000 years," while one at top is not twenty years old, and of short distance of travel.

From such facts Dr. Croll argues that the ice of the Antarctic ice barrier moved off from a low and even land surface, and that this kind of surface characterizes the "Antarctic continent." On the ground that the moist winds flow in all directions toward the south pole, and that the latitudinal extent diminishes poleward, it is urged that the loss by precipitation on going poleward does not necessarily occasion a diminishing depth of ice. For if the annual amount of precipitation between the parallels of 60° and 80° is thirty feet, and the amount of moisture left in the air on reaching the line of 80° is only a tenth of thirty, this tenth would give a snow fall there of twenty-four inches, because the area between the line of 80° and the pole is only an eighth of that between the parallels of 60° and 80°. Hence even if the border of the Antarctic ice region takes from the clouds the greater part of their moisture, the thickness of the ice may still increase poleward. Moreover, the region of the pole should be ever filling with ice, however small the precipitation.

Dr. Croll regards the recent observations of Nordenskjöld as confirmatory of his views on Arctic and Antarctic ice regions.—*Amer. Jour. of Science.*

OUR ANIMAL ENEMIES AND ALLIES RECONSIDERED.

SCANTY as is the British fauna, our knowledge of its relation to human needs and conveniences is by no means complete. Almost every season we notice fresh features in the habits and character of some apparently well known species which must be taken into account when the question of its preservation or destruction has to be raised. In such cases we cannot help asking whether our forefathers have merely omitted to record some old fact, or whether the species in question are developing new habits? On this point no general law can be laid down. We know that changes of diet have been distinctly traced, as in the New Zealand parrot and the South African baboon, both of which have quite recently acquired a taste for mutton. In like manner, if we turn over the zoological literature of the past, we find the common squirrel invariably spoken of as perfectly harmless, living upon nuts and acorns. Yet if we consult modern gardeners whose lot has been cast in well-wooded districts, or if, better still, we contrive to make observations in person in such a neighborhood, we shall find cause to regard this elegant little animal as a tree-rat meriting little toleration at our hands. He now varies his traditional diet with wall-fruit, and occasionally with pears and apples, carefully selecting the finest specimens. His depredations of this kind are not mere matter of conjecture; again and again, in the stillness of an early summer morning, he has been watched in the very act of gnawing peaches; the marks of his teeth in pears, etc., are also quite distinct from the peckings of birds.

But there is another charge against the squirrel: In shrubberies undisturbed by human depredators we may one day observe a bird sitting peacefully upon her eggs; the next day we find the nest all pulled to pieces, the eggs gone, and the parent birds flown to seek some safer spot. This mischief is also due to the squirrel. Accordingly, if one of these buff-colored rodents makes his appearance in a grove during nesting time, the alarm and dismay of the birds is almost as striking as if a hawk were seen hovering overhead or a weasel were running up the tree. Egg eating appears to be distinctly one of the squirrel's modern accomplishments. Whether he confines his attacks to the nests of tree haunting species, or occasionally indulges in a raid upon the eggs of the partridge and the pheasant, we cannot say with certainty. Still, from certain suspicious facts, we should commend him to the jealous scrutiny of the gamekeeper.

As far as the smaller birds are concerned, however, not merely the eggs but the callow young are exposed to the attacks of Bunny. Hence, for our part, we feel no hesitation in signing his general death warrant.

But to find a means for carrying out the sentence is difficult. It is rarely possible to get a fair shot at him if he knows that you are in pursuit, as he dexterously contrives to keep the stem of a tree or a thick branch between himself and the source of danger. Sometimes in the twilight of a summer evening a family party of squirrels will come down to have a dance on the lawn, and may then be struck down if a loaded gun is at hand. In his early morning raids in the garden, too, he sometimes may be found within range in the open. Dogs and cats pursue him, but they are almost equally inefficient. We think, indeed, that a cat has more chance of catching a bird than a squirrel.

As for his wild enemies, the weasel and the polecat—which occasionally surprise him in his nest by night or in his winter retreats—cannot be encouraged where poultry or game are being reared. The same objection applies to the carrion crow, the raven, and to certain hawks. The larger owls are probably his best and most trustworthy opponents, and should from a variety of grounds be preserved and encouraged. Much might be done toward the extirpation of the squirrel by careful search during the winter in the hollows of trees. How is it that no one has yet devised a squirrel trap?

Passing from mammalia to birds, we are sorry to find that not a few are far from improving on a closer acquaintance. The number of purely zoophagous species which do not admit more or less vegetable matter—seeds, fruits, etc.—into their dietary is not large. We may even ask whether among those birds which remain with us throughout the year there are, save the birds of prey, commonly so called, any purely zoophagous forms? In a severe winter the supply of insects, worms, slugs, etc., is often interrupted for so long a time that a bird incapable of digesting seeds, berries, etc., would be in great peril of starvation.

Among the more useful wild birds the starling has long held high rank as a vermin-destroyer. The German farmers from time immemorial have been in the habit of fixing up small boxes in their orchards, in which this bird may build its nest, secure from cats, hawks, owls, etc. We have often heard the opinion expressed by intelligent and observant men, that the protection thus afforded to the starling was well remunerated. Nevertheless, every one must have seen this bird feasting upon the red currants in our gardens and have heard it protest with angry screams when the fruit is being gathered and carried away.

The jay, as a member of the same group, the Corvidæ, by repute zoophagous, is for the most part denounced—mainly by game-preservers—as a suspected destroyer of the eggs of pheasants and partridges, and defended by lovers of birds as an eradicator of caterpillars and other noxious insect-larvæ. It may be, however, that his main disservices to man are to be witnessed in the orchard and the kitchen-garden rather than in the game-preserve. The skill with which he extracts peas and beans from the pod, leaving it apparently intact until it collapses on handling, is worth notice. The scarlet-runner and the kidney bean do not seem to meet his taste at any stage of their growth. Gooseberries the bird attacks in a similar style, making a small opening with the point of his beak, sucking out the pulp, and leaving the empty skin hanging. The jay is decidedly a neat feeder. Whether his good deeds among cockchafers, elaters, and noxious larvæ fairly compensate his work among various crops is hard to decide.

The thrush group, as it has been often pointed out, hold also an ambiguous position. Did they merely take "a little fruit"—as certain writers euphemistically express it—they might live in our good graces. But where they are plentiful and have been fed through the winter they display their gratitude by taking "not some, but all." Long before the crop is ripe they make numerous trial borings, never finishing a fruit. The damage thus begun is carried on by wasps, flies, earwigs, etc., and by rain, and the fruit in consequence rots before it can ripen. Scarecrows, however cunningly devised, lose their terrors in at most three or four days. Nets are not easily applied to standard trees, and are in any case certain to keep off an appreciable portion of the sunshine, rarely too abundant in Britain.

Last, and worst of the feathered race comes the sparrow. Not, indeed, that a particle of evidence has turned up in his favor. All the intelligence that comes to hand from countries where he has been indiscreetly acclimated—*e. g.*, the United States—points in one and the same direction. Careful observers there have not merely watched closely the doings, the goings, and comings of the sparrow, but have from time to time shot a specimen, and opening his crop made an examination of its contents. The result has been most condemnatory; three-fourths at least of the food of the sparrow are in this manner proved to consist not of caterpillars, gnats, and the like, but of fruit, grain, and other matter which man preserves to reserve for his own consumption. We can pronounce this bird, therefore, frugivorous from choice and occasionally insectivorous from necessity, with a general tendency to mischief. Thus one observer, finding the sparrows apparently hard at work in some vines, left them for a time unmolested, in the belief that they were ridding the vines of some injurious insect. On closer examination he found that they were biting off the fruit-buds, eating, however, little of what they thus destroyed but throwing the fragments to the ground in superfluity of naughtiness. The owner's prospect of a crop of grapes for the season was thus effectually cut off.

Another sin of the sparrow is manifested as strikingly in America as in Europe—the war, too often successful, which it wages against the harmless and useful swallow. The helpless young swallows are often dragged from the nest and thrown to the ground, and the parent birds, on their return, find the hateful enemy in possession. We fear, from a variety of facts which come under our notice, that the swallow and the martin are becoming decidedly less abundant in Britain, and that this decrease is owing in great part to the increase of the sparrow. We know an instance of a mansion in Essex, standing in its own grounds of about 80 acres, where the swallows were till lately very numerous. They were considered by the proprietor and his family as most welcome visitants, since the neighborhood is in summer much infested with gnats and midges. But though protected from all ordinary forms of molestation they have gradually become less and less numerous, and this year, if we remember rightly, none at all have put in an appearance. In former seasons it has repeatedly happened that their young brood has been thrown down by the sparrows, and more than once an intruding hen sparrow has suffered death on being caught in a swallow's nest.

Now if we remember that gnats are found to be not a mere irritation or annoyance, but conveyers of disease, the preservation of the swallow and of every gnat destroyer becomes a point of sanitary policy, and is consequently a national concern. The question therefore arises whether a war of extirpation against the sparrow should not be undertaken in a more general and systematic manner than has heretofore been the case.

Turning from birds to batrachians we find a shade of doubt attaching to the toad—an animal which we have hitherto regarded as an unimpeachable friend. His services against slugs, wood lice, and a number of garden pests are generally recognized. But we have heard it latterly asserted, by persons whose evidence is entitled to some respect, that he has been seen in the very act of devouring strawberries. We by no means consider the proof sufficient, and hope that our sober friend may yet be found entitled to an honorable acquittal. But we recommend close observation during the ensuing season. Nothing short of being seen in the very act ought to suffice, since a bitten strawberry may be, and generally is, the work of snails or slugs. All our knowledge, indeed, concerning the habits of the toad and his allies militates plainly against his proving to be a fruit eater, but we have had abundant proof that the habits of animals often differ strikingly from what their structure and their affinities seem to warrant.

Concerning noisome and destructive insects there is this season but little to remark. The crane fly, or daddy long-legs (*Tipula oleracea*) has been found in many parts of England in almost unexampled numbers; so that, unless its egg and larvæ meet with some destroying agent before the spring, there is every reason to fear that the grass and the corn must suffer heavily. The slaughter made among this enemy by birds, spiders, etc., seemed quite a vanishing quantity when compared with the millions remaining.

The house-fly has been in many places less abundant than usual. We have even met with persons ill-informed or injudicious enough to consider this scarcity an evil omen in a sanitary point of view.

The blowfly appears to have an especial fondness for ivy-blossom—a tendency not easy to understand, since the ivy certainly gives off no odor at all similar to that of tainted meat.

Wasps have been locally plentiful, and very destructive to fruit. Their nests are now preferably attacked by means of petroleum. The exact position is marked in the day-time, and after nightfall the nest is drenched with half a gallon of petroleum, more or less according to size, and ignited either by means of a match or by firing a blank cartridge into the mass. This method is far safer and more efficient than the old methods of digging out, blowing up with gunpowder, etc. We now think that the extirpation of wasps may be undertaken with little scruple, since the chief service which they render, the destruction of blowflies, can be better effected by other methods. In the fertilization of flowers wasps play but a very subordinate part.

Earwigs have been unusually scarce, as far as we have been able to observe, and the gooseberry caterpillar and moth (*Abraxas grossulariata*) has in many gardens been totally absent.

Altogether insects of all the orders have been exceptionally scarce—a fact ascribed by some to the extremely damp character of the last winter, when many larvæ, and especially pupæ, must have become mouldy.

On recapitulating the above facts we cannot help seeing that the old absolute distinction made between the "carnivorous" and "herbivorous" animals is, like most such dualistic classifications, no longer tenable. With the great exception of the ruminant group, whose highly specialized digestive organs are adapted to deal with huge quantities of a sparingly nutritious mater, the majority of mammals are omnivorous, capable of adapting themselves either to an animal or a vegetable diet, or to a mixture of both. This conclusion is not merely fatal to one of the dogmas of the Old Natural History, but militates against the fundamental principles of the Vegetarian movement.—*Journal of Science.*

"TIME" notes are now numerous. One correspondent in the far West suggests making the day commence at 6 o'clock in the morning, the hours running up to 24; the year to be divided into 13 months of 28 days each, and the odd day to be called Independence Day, in token that we have absolved ourselves from the system of counting time imposed upon the world by Julius Cæsar.

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